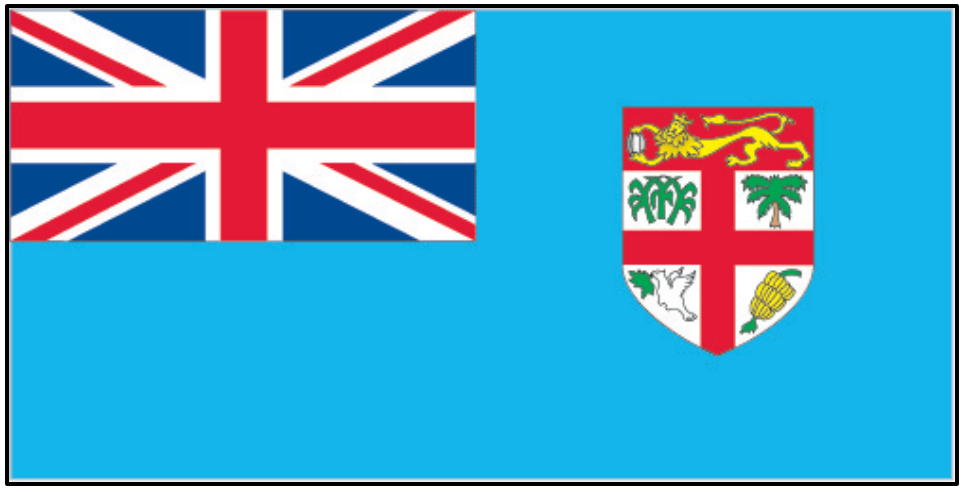
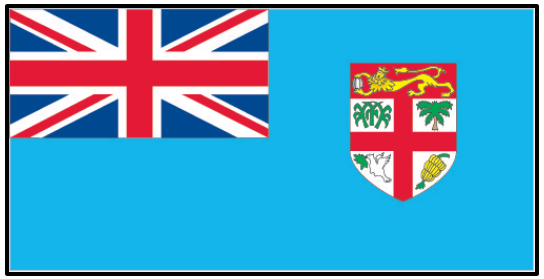
Appendix B

Detailed PICT Outlooks



H_2 Case Study:

Fiji



Overview

Population
- 925,000

Gross Domestic Product
- USD $5.5 B
- FJD $12.2 B

Land Area
- 18,274 km^2
- 24% agricultural land
- 56% forested land

Fossil Fuel Consumption
- 5.4 TWh
- 75% of annual energy use

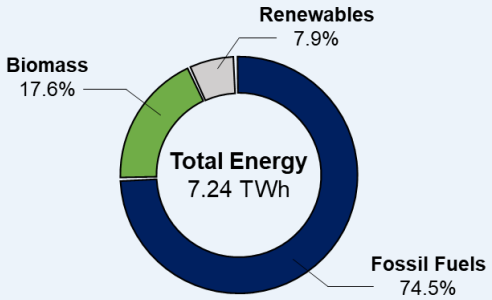
GDP Spent on Fossil Fuel Energy
- 5.7 %
- USD $0.31 B
- FJD $0.69 B

CO_2 Emissions
- 2.3 Mt of CO_2e per year
- 1.5 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

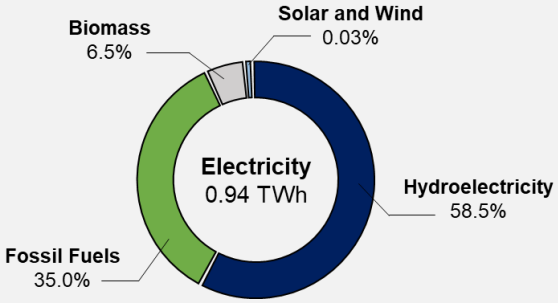
Energy Outlook

- Fiji's annual energy use is around 7.24 TWh, 75% of which is fossil fuel-based.
- Fiji imports 5.4 TWh of energy as various oils, primarily diesel (equivalent to 3.4 million bbl of diesel).
- Most energy is used in the transport sector, as well as in the manufacturing, construction, and mining industries.



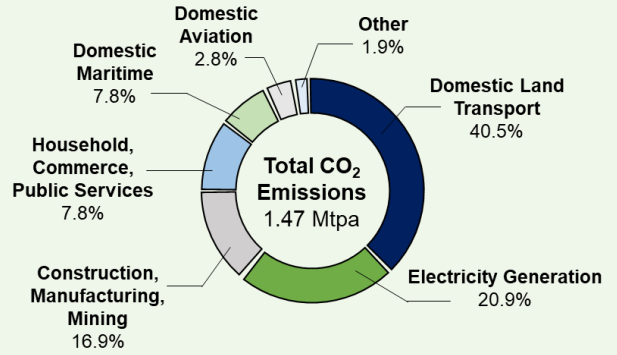
Electricity Mix

- Fiji produces almost 60% of its electricity as hydroelectricity, with over one-third of electricity produced using diesel generators.
- Biomass is used as a minor source of electricity by independent power producers, including the sugar and wood industries that use waste biomass for power and heat.
- A 10 MW wind farm and small solar systems round out the electricity mix.
- Around 90% of Fiji currently has access to electricity.



CO_2 Emissions

- Fiji's total greenhouse gas emissions are 2.3 Mtpa of CO_2e.
- CO_2 emissions total 1.5 Mtpa, whilst the remainder of emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- Over 60% of CO_2 emissions can be attributed to domestic land transport and electricity generation.



Hydrogen Potential

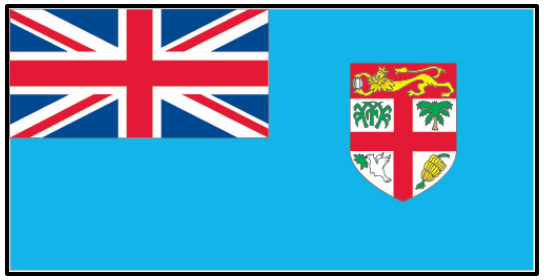
- A significant expense is associated with the fossil fuel use in key sectors, most notably domestic land transport, which costs USD $128 M per year.
- Around 116,000 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	718,000	66.1	6,700	17,000	34,000
Domestic Land Transport	1,390,000	128	13,000	33,000	65,000
Domestic Maritime Transport	270,000	24.8	2,500	6,300	13,000
Domestic Air Transport	95,200	8.76	890	2,200	4,500

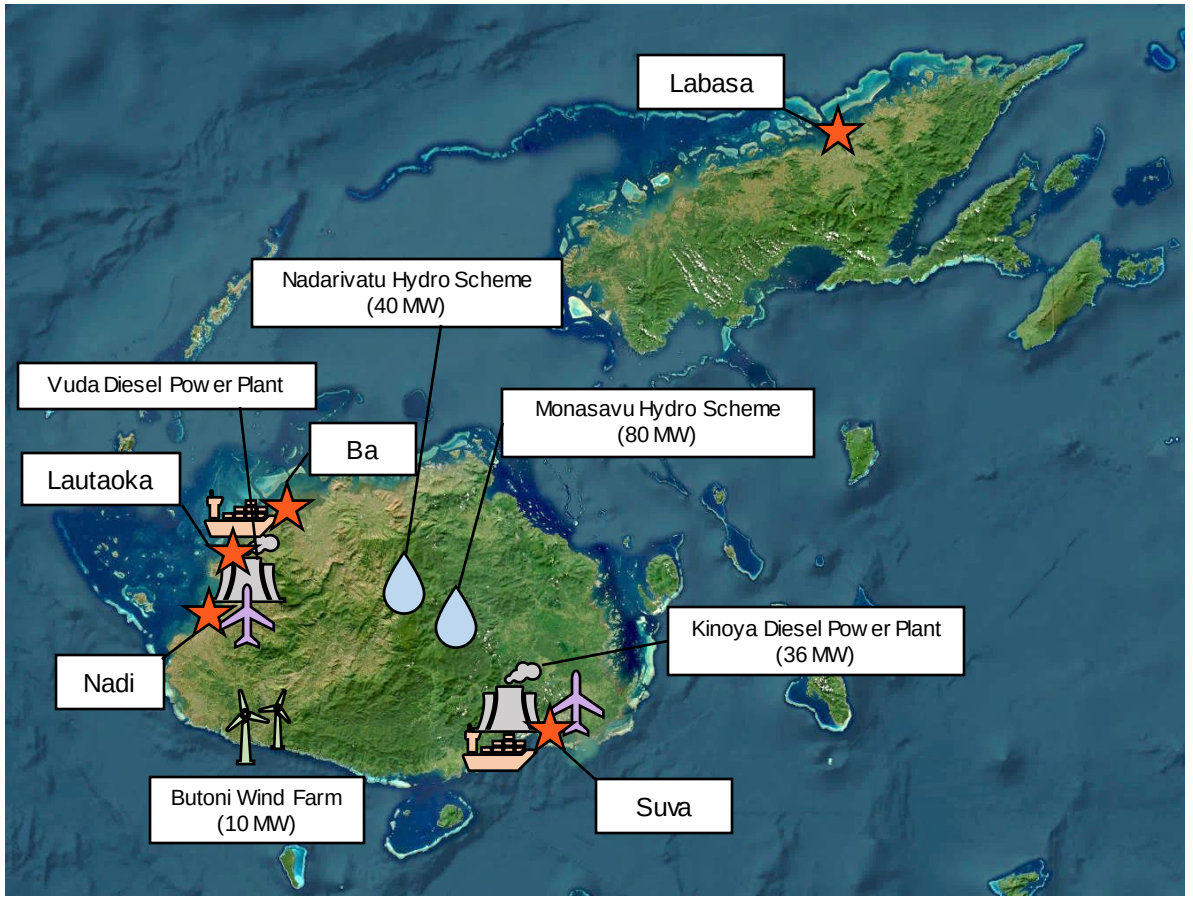
Targets

- Fiji has a target to achieve net zero emissions by 2050.
- This includes a target to reduce emissions from the energy sector by 30% by 2030. This will be achieved by:
  - Targeting 100% renewable power generation (by 2030).
  - Reducing energy sector CO_2 emissions by 10%.
  - Reducing domestic maritime shipping CO_2 emissions by 40%.

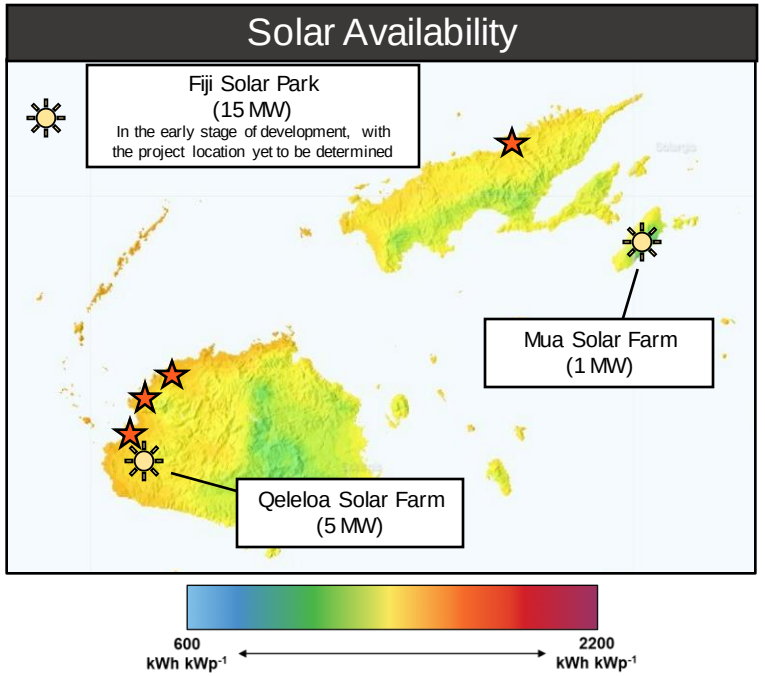


Legend

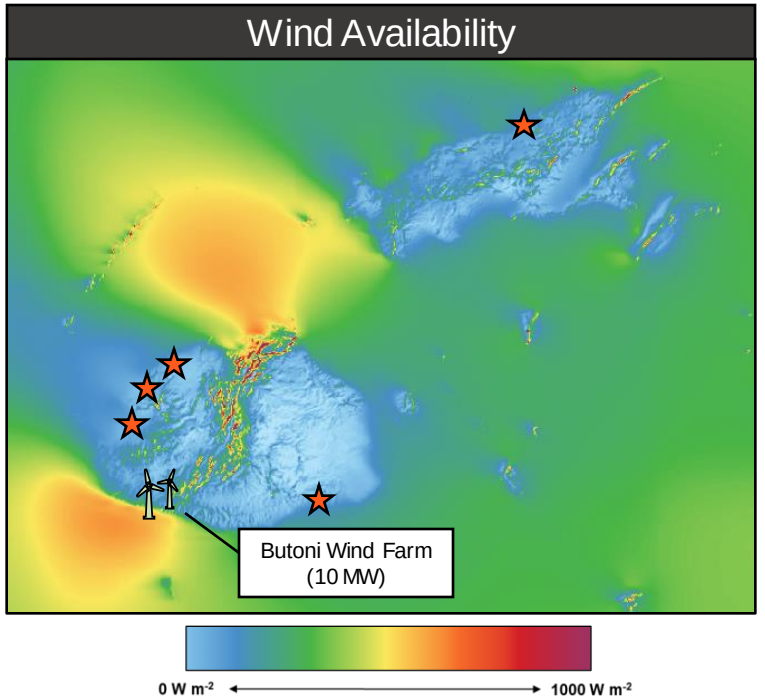
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



Population

- Fiji consists of around 330 islands, of which 110 are inhabited.
- The main islands of Vanua Levu and Viti Levu account for around 87% of the total population.
- More than 75% of Fijians live on the coasts of Viti Levu.
- The capital and largest city is Suva, which together with surrounding areas accounts for a combined third of the total population.

Renewable Energy Potential

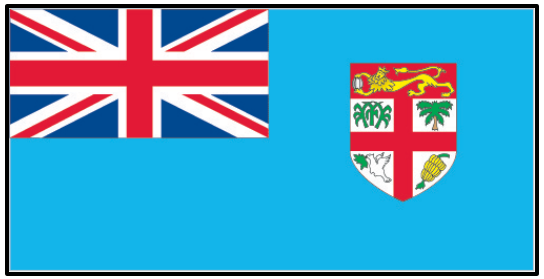
- The highest solar availability is around the cities of Ba, Lautaoka, and Nadi.
- The highest wind availability is through the centre of Vitu Levu to the north and south coasts (where the Butoni wind farm is located).
- The most densely populated areas do not receive a high wind energy density.

- The production of 116,000 tpa of hydrogen would require around:

5.8 TWh/yr of electricity

660 MW of electrolyser capacity

3.5 GL/yr of water



Fiji's Power to X Potential

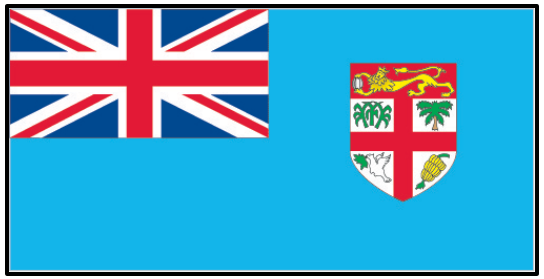
Fiji is reliant on fossil fuels for 75% of its energy needs, particularly in the mobility sector and electricity generation – almost all of which is imported, putting strain on the local economy. A shift to Power to X can enable energy security, especially in the maritime, heavy transport, and aviation industries, which are critical drivers of the local economy and connectivity with the rest of the world.

Existing Targets and Strategies for Decarbonisation

- Fiji is targeting 100% grid-connected renewable power generation by 2030 in their NDC. They are on track to achieve this target – Hydropower (the largest of which is the Wailoa Hydro Power Station – 80 MW capacity) currently accounts for almost 60% of electricity generation, and the country is developing the Energy Fiji Solar Park – 15 MW, expected to be operational by 2024.
- Targets for decarbonisation of the energy sector by 2030 include:
  - Reducing the population relying on wood fuels for cooking.
  - Increasing the renewable energy share of electricity generation to 100% through new hydropower installations (120 MW), solar PV (25 MW), and biomass (10 MW) together with the improvement and extension of transmission and distribution networks. Increasing installed household solar systems.
  - Installing hybrid systems and mini-hydro systems.
- Fiji has ambitions to become net zero by 2050. Strategies to achieve this include:
  - Introduction of low-carbon domestic transport vehicles including hybrids, Plug-In Hybrid Electric Vehicles (PHEVs), and Electric Vehicles (EVs), expanding public transport, and introducing biofuels.
  - retrofitting and replacement to energy/carbon efficient propulsion and hull design for maritime transport, the use of smaller, more efficient craft that are suited to inter-island routes, and the introduction of renewable energy (biofuel, solar, hydrogen fuel cells, or sail assisted) vessels.
  - Introduction of SAF-powered planes and short-haul electric planes for domestic aviation.
  - Installation of solar (272 MW), wind (150 MW), geothermal (52 MW), and biomass (136 MW) facilities to provide the renewable energy needed, under a scenario in which current policies and targets are implemented, that rely on external or international financing.
  - Reforestation and a reduction in deforestation action, and management of mangrove systems.

Figure 1. View of the Nadarivatu Dam.

Figure 2. Ferries and cruises are critical means of connecting between Fijian Islands.



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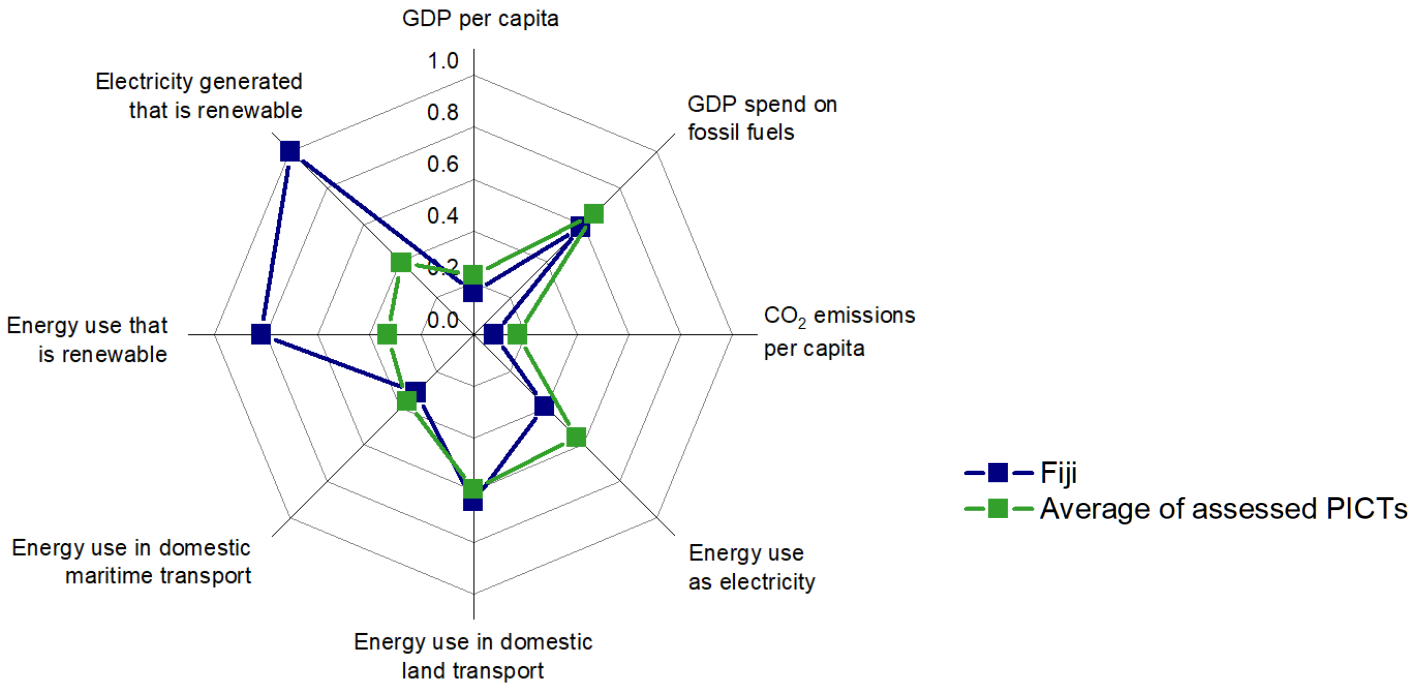
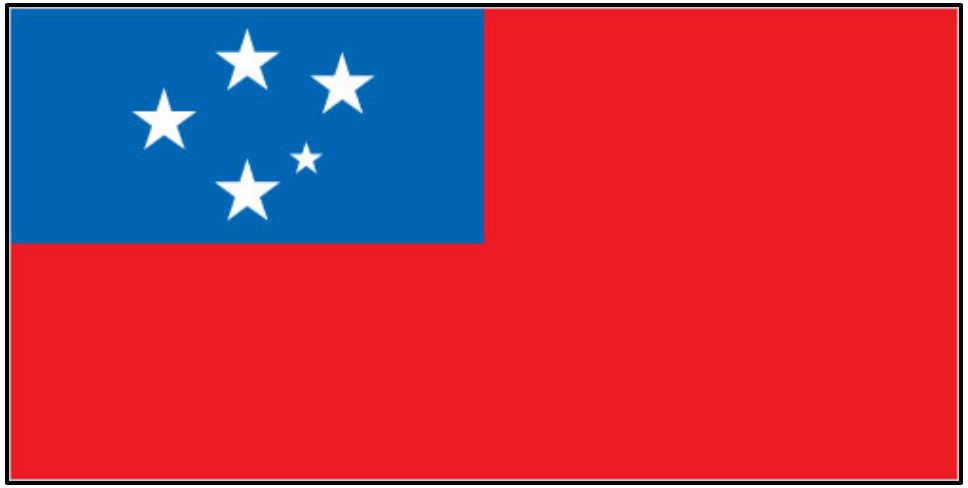
Competitive Advantage



- Regionally, Fiji is one of the most advanced in renewable energy capacity – including hydro and bioenergy (Second only to PNG).
- Fiji also has acceptable solar (8th highest in PICTs) and strong wind (3rd highest in PICTs) energy potential with up to 90% energy accessibility/coverage.
- Fiji's comprehensive decarbonisation policies create a strong foundation for Power to X and for the country to become a climate leader and source of knowledge in the Pacific, as well as an exporter of clean fuels in the Pacific.

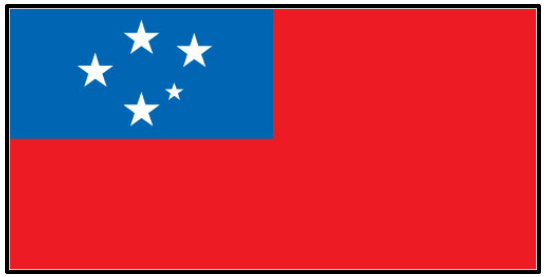
Critical Challenges

- Fiji is particularly vulnerable to floods and cyclones – Cyclone Winston in 2016 caused around 80% of the population to lose power, totaling almost USD $1.0 B in damages. Any infrastructure must therefore be developed and implemented in consideration of the type and increasing frequency of such natural disasters. In particular, hydropower facilities and electricity transmission lines are at increased risk.
- The population and infrastructure (including water, energy, and transport systems) are heavily concentrated on the coasts and are therefore particularly exposed to both the rise in sea levels and such natural disasters.
- Decarbonisation of the maritime industry (key for connections between islands) is difficult due to a lack of research and development in the maritime sector in comparison to other energy use sectors.
- Key challenges for decarbonisation include:
  - A lack of adequate data.
  - Insurance and financing.
  - Human capacity.
  - Enabling policies.
  - Obsolete machinery and old infrastructure and buildings.
  - The need for a whole-of-sector approach to consultation and implementation including all key stakeholder groups.



H_2 Case Study:

Samoa



Overview

Population
- 222,000

Gross Domestic Product
- USD $0.91 B
- WST $2.5 B

Land Area
- 2831 km^2
- 12% agricultural land
- 60% forested land

Fossil Fuel Consumption
- 1.1 TWh
- 70% of annual energy use

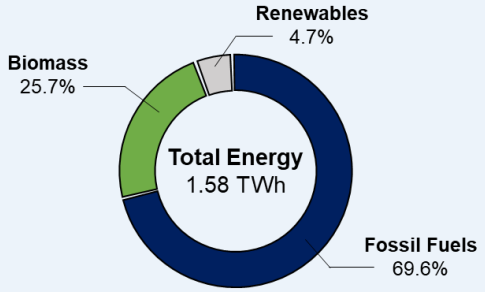
GDP Spent on Fossil Fuel Energy
- 6.9 %
- USD $63 M
- WST $171 M

CO_2 Emissions
- 0.61 Mt of CO_2e per year
- 0.29 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

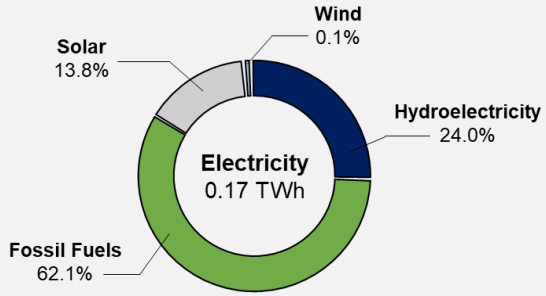
Energy Outlook

- Samoa's annual energy use is around 1.58 TWh, 70% of which is fossil fuel-based.
- Samoa imports 1.1 TWh of energy as various oils, primarily diesel (equivalent to 0.69 million bbl of diesel).
- Most energy is used in domestic land transport and for electricity, as well as in the manufacturing, construction, and mining industries.



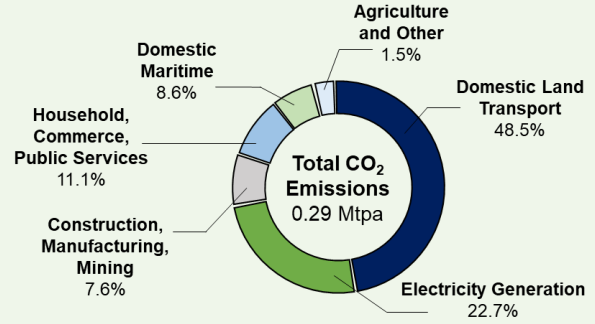
Electricity Mix

- Samoa produces over 60% of its electricity from fossil fuels.
- Hydroelectricity accounts for most of the renewably-generated electricity, at 24%.
- Almost 14% of electricity is generated by solar through independent power producers, whilst only 0.13% is generated by wind.
- The 750 kW Afolau biomass gasification project also contributes to electricity generation.



CO_2 Emissions

- Samoa's total greenhouse gas emissions are 0.61 Mtpa of CO_2e.
- CO_2 emissions total 0.29 Mtpa, whilst the remainder of emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- Over 70% of CO_2 emissions can be attributed to domestic land transport and electricity generation.



Hydrogen Potential

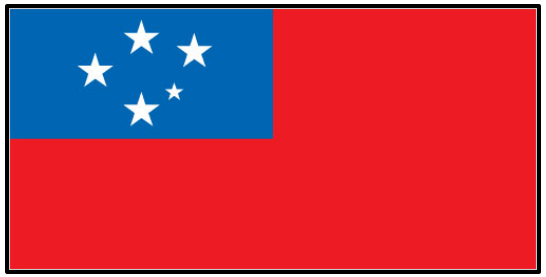
- A significant expense is associated with the fossil fuel use in key sectors, most notably domestic land transport, which costs USD $31 M per year.
- Around 26,000 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	156,000	14.3	1,500	3,700	7,300
Domestic Land Transport	334,000	30.7	3,100	7,800	16,000
Domestic Maritime Transport	59,400	5.47	560	1,400	2,800

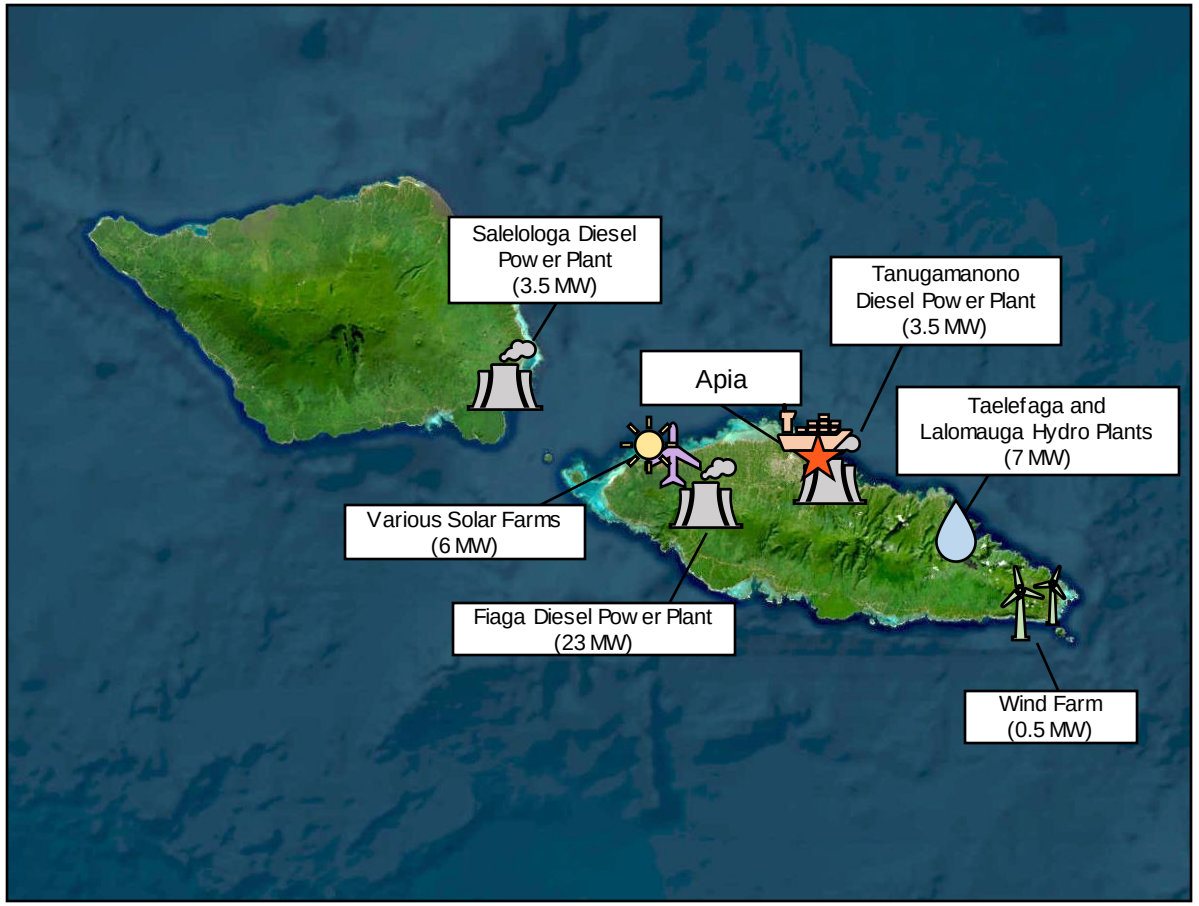
Targets

- Samoa has a target to generate 100% of electricity renewably by 2025.
- Reducing CO_2 emissions by 26% by 2030 (compared to 2007 levels) is targeted by:
  - Reducing GHG emissions in the energy sector by 30% by 2030.
  - Reducing GHG emissions in the waste sector by 4% by 2030.
  - Reducing GHG emissions in the AFOLU sector by 26% by 2030.
- Samoa is targeting net zero emissions by 2050 through the Climate Ambition Alliance.

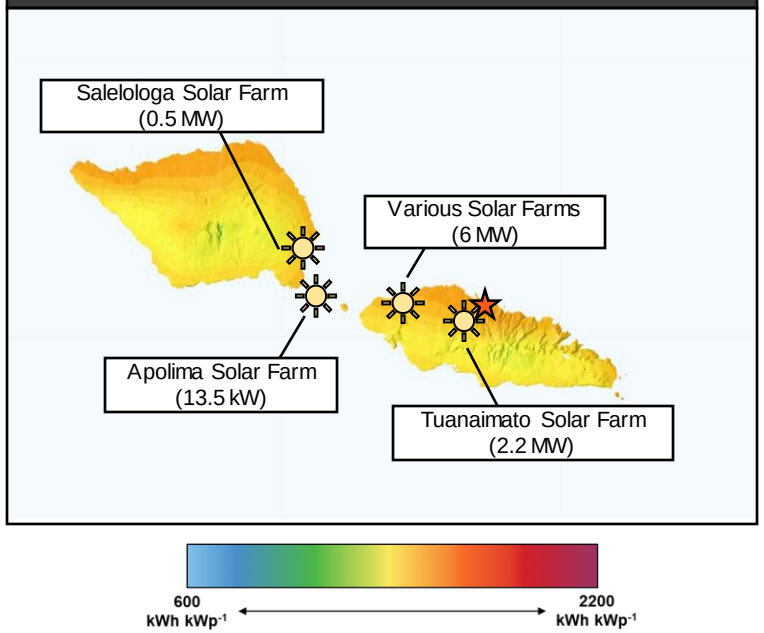


Legend

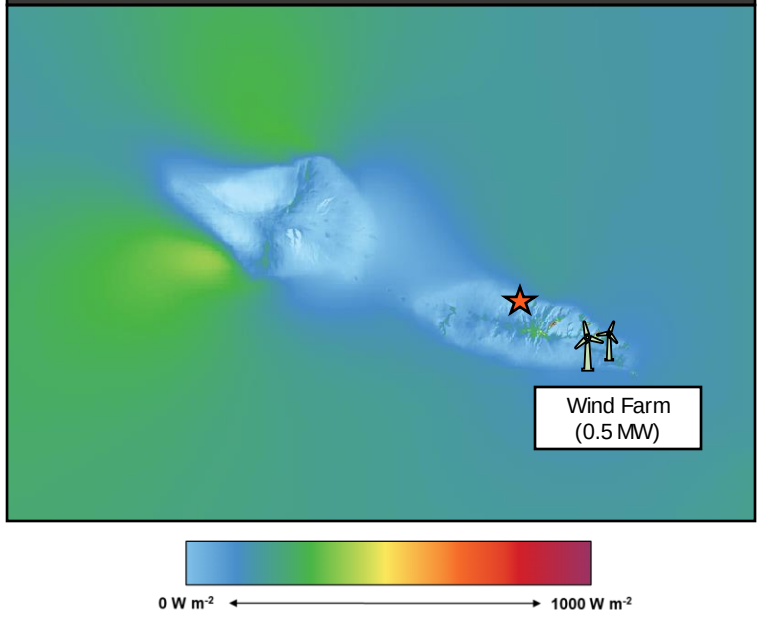
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



Population

- Samoa consists of two main inhabited islands, as well as two smaller inhabited islands and five uninhabited islands.
- Upolu, the main island, accounts for around 77% of the total population, whilst Savai'i accounts for a further 22%.
- The capital city of Apia has a population of over 40,000.
- Around 80% live in rural areas.

Renewable Energy Potential

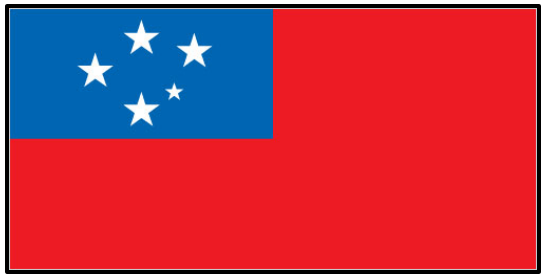
- Samoa receives a fairly consistent level of solar energy across the two main islands, with higher availability at the northern coasts.
- In general, the wind availability is low across the two main islands, with small areas of high wind energy density on the eastern side of Upolu, where a 0.5 MW wind farm has been constructed.

- The production of 26,000 tpa of hydrogen would require around:

1.3 TWh/yr of electricity

150 MW of electrolyser capacity

0.77 GL/yr of water



Samoa's Power to X Potential

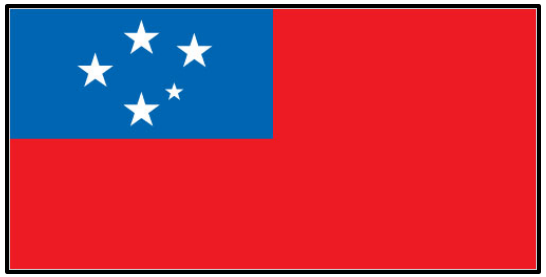
Samoa relies on fossil fuel for 70% of its energy needs, particularly for energy generation and for domestic land transport on the two main islands. A shift to Power to X can enable energy security in these sectors, as well as alleviating energy-related constraints on its fisheries, agricultural exports, and tourism. Samoa has high potential for large-scale solar energy generation.

Existing Targets and Strategies for Decarbonisation

- Samoa, as part of its 2021 NDC, has set a target of reducing its emission footprint by 26% (compared to 2007 levels) by 2030, with a primary focus on reduction from the energy sector (30% reduction), waste (4%) and agriculture/forest sector (26%).
  - The emission reduction from the energy sector will be primarily driven by an increase in renewable generation capacity, electrification of the mobility sector and transition to low-carbon fuels (mainly in land and marine transport). This includes use of solar panels and biofuels for powering maritime transport. All of these targets can be covered under the Power to X umbrella.
  - Emissions from waste will be reduced by implementing landfill gas capturing technologies to Samoa's landfills.
  - GHG emissions in the AFOLU sector will be reduced by (i) improving agriculture practices through improved manure management and fertiliser use, (ii) reforestation, forest restoration, and promoting agroforestry, and (iii) mangrove restoration and planting programs in coastal areas.
- Samoa notes that they would require external financial support and technical assistance in achieving these goals.
- The Samoan Government has also targeted achieving 100% renewable-driven electricity by 2025. An ambitious target as, at present, <50% of the electricity generation capacity is powered by fossil fuels. The local electricity provider, Electric Power Corporation, estimates an additional investment of USD $100 M would be required to achieve the renewable energy targets.
- Samoa's NDC does not specify a target of net zero emissions by 2050, however they are a member of the Climate Ambition Alliance, which aims to reach net zero in the 2040s or sooner, or by midcentury at the latest.

Figure 3. The Fiaga diesel power plant provides ~60% of Samoa's electricity needs.

Figure 4. Apia Port. The port serves as a regional trade hub and gateway between Samoa and the Pacific (cruise lines).



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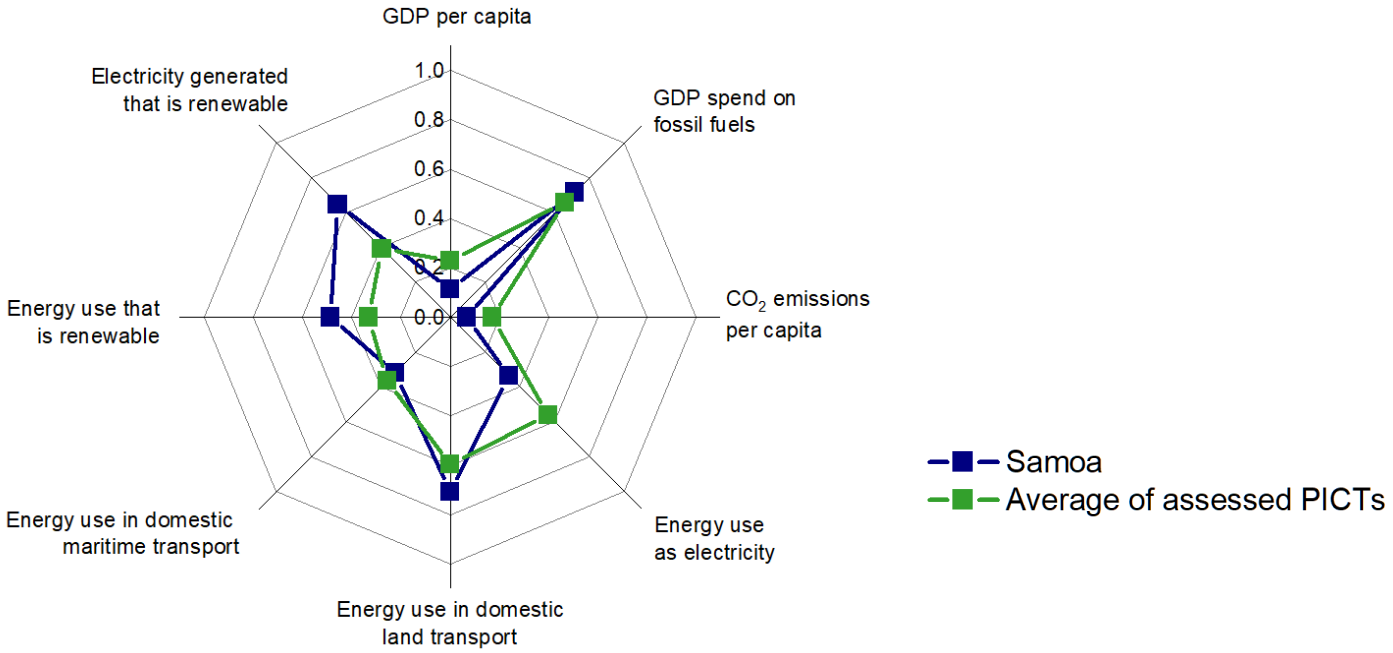
Competitive Advantage



- Regionally, Samoa is relatively advanced in renewable energy capacity – with hydro power, solar power, and wind power installations making up around 40% of the electricity generated. However, the country spends a high proportion of its GDP on fossil fuels.
- Samoa has strong solar (5th highest in PICTs) but low wind (9th highest in PICTs) energy potential with up to 100% energy accessibility/coverage.
- Due to the concentration of the population on the two main islands, Samoa can heavily decarbonise through the domestic land transport sector, which is more developed compared to maritime and air transport decarbonisation.

Critical Challenges

- Samoa is at risk to tropical cyclones, tsunamis, droughts, and floods. Changing weather patterns and natural disasters are impacting Samoa's settlements, as 70 % of the population and infrastructure are located in low-lying coastal areas.
- Natural resources are critical to Samoa's main economic sectors of fisheries, agriculture, and tourism. Exports of primary products are subject to constraints, such as price instability, high transport costs, lack of overseas markets, and harsh weather conditions.
- Decarbonisation of the maritime industry (key for connections between islands) is difficult due to a lack of research and development in the maritime sector in comparison to other energy use sectors.
- Key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.

H_2 Case Study:

Vanuatu

Overview

Population
- 327,000

Gross Domestic Product
- USD $0.98 B
- VUV $116 B

Land Area
- 12,189 km^2
- 15% agricultural land
- 36% forested land

Fossil Fuel Consumption
- 0.65 TWh
- 72% of annual energy use

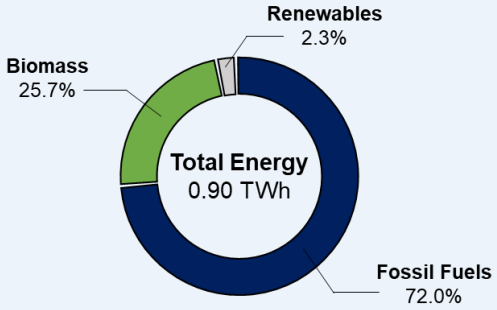
GDP Spent on Fossil Fuel Energy
- 3.8 %
- USD $37 M
- VUV $4.4 B

CO_2 Emissions
- 0.85 Mt of CO_2e per year
- 0.18 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

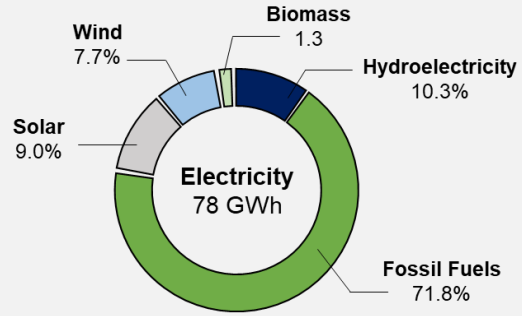
Energy Outlook

- Vanuatu's annual energy use is around 0.90 TWh, 72% of which is fossil fuel-based.
- Vanuatu imports 0.65 TWh of energy as various oils, primarily diesel (equivalent to 0.41 million bbl of diesel).
- Most energy is used in domestic land transport and for electricity, making up over 85% of total energy usage.



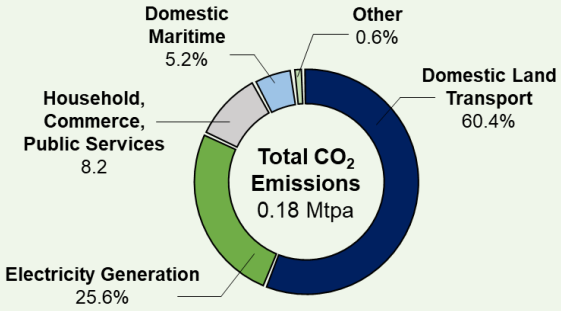
Electricity Mix

- Vanuatu produces over 70% of its electricity from fossil fuels.
- Hydroelectricity accounts for most of the renewably-generated electricity, at 10.3%, followed by solar (9.0%) and wind (7.7%).
- The main biomass sources in Vanuatu are fuel wood and coconut residues, which over 40% of the country use for cooking fuel.
- Vanuatu aims to replace diesel energy with coconut (copra) oil-based electricity generation to achieve 100% renewable electricity generation.



CO_2 Emissions

- Vanuatu's total greenhouse gas emissions are 0.85 Mtpa of CO_2e.
- CO_2 emissions total 0.18 Mtpa, whilst most emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- Over 85% of CO_2 emissions can be attributed to domestic land transport and electricity generation.
- Minor contributions are seen from households and domestic maritime.



Hydrogen Potential

- A significant expense is associated with the fossil fuel use in key sectors, most notably domestic land transport, which costs USD $23 M per year.
- Around 17,000 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

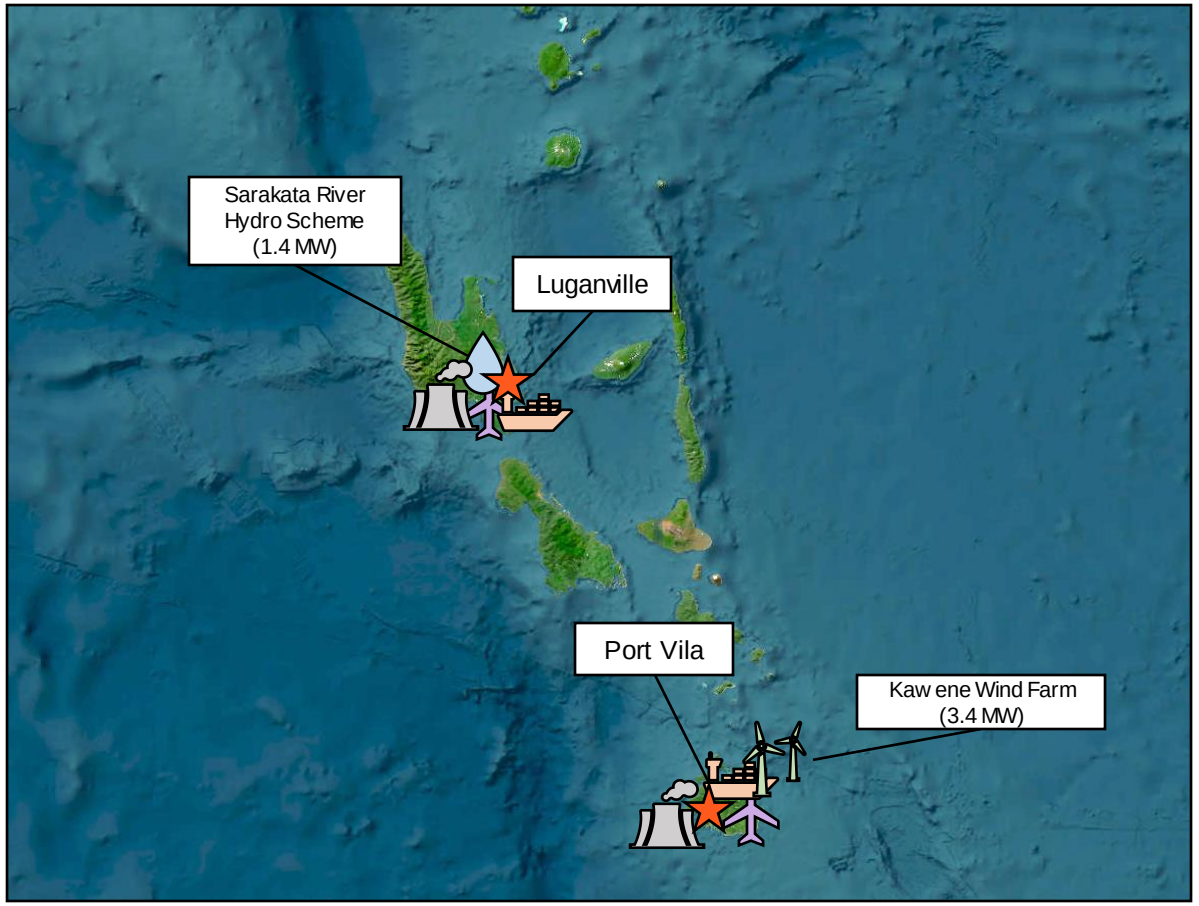
Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	34,900	9.63	980	2,500	4,900
Domestic Land Transport	247,000	22.7	2,300	5,800	11,600
Domestic Maritime Transport	21,000	1.94	200	490	990

Targets

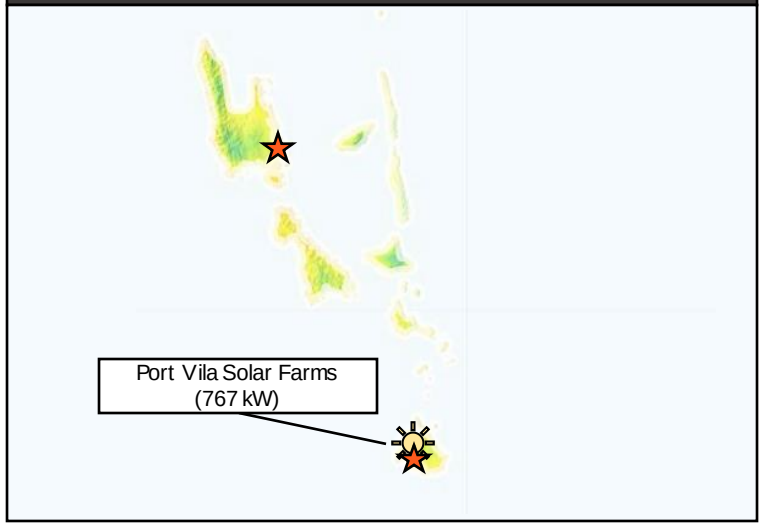
- Vanuatu has a target to generate 100% of electricity renewably by 2030.
- Reducing CO_2 emissions by 30% in the energy sector is targeted by:
  - Achieving a 10% improvement in land and marine transport by 2030.
  - Introduction of electric vehicles and bio-diesel.
  - Installation of 1000 biogas plants by 2030.
- Vanuatu is targeting net zero emissions by 2050 through the Climate Ambition Alliance.

Legend

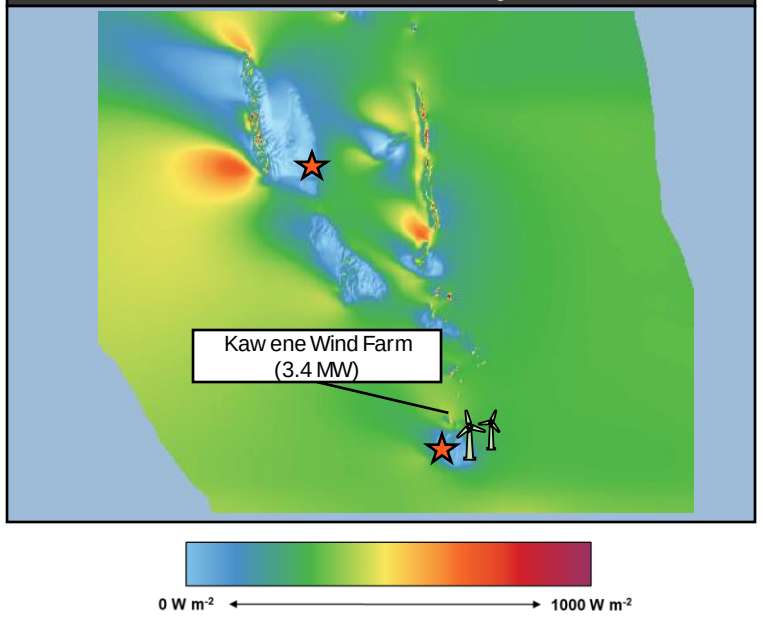
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



Population

- Vanuatu consists of around 83 small islands, of which around 65 are inhabited.
- The main cities of Port Vila and Luganville have populations of around 50,000 and 15,000, respectively, equivalent to around 20% of the population.
- The majority of the population live in rural areas.

Renewable Energy Potential

- Vanuatu receives an average level of solar energy across the main islands
- Areas of high wind availability are seen off the coasts of the main islands, for example at the southwestern corner of Espiritu Santo.
- Rooftop solar and various solar farms in Port Vila are in operation, whilst the Kawene wind farm provides wind power to Port Vila.

- The production of 17,000 tpa of hydrogen would require around:

0.87 TWh/yr of electricity

100 MW of electrolyser capacity

0.52 GL/yr of water

Vanuatu's Power to X Potential

Vanuatu is one of the most disaster-prone countries, that will be significantly affected by climate change. Vanuatu has targeted renewable electricity generation by 2030, and has put forwards measures to reduce emissions from the agricultural sector, which is responsible for the majority of emissions. Power to X can assist in decarbonising land transport, which is a significant contributor to emissions.

Existing Targets and Strategies for Decarbonisation

- Vanuatu, as part of its 2021 NDC, has set a target of transitioning to close to 100% renewable energy in the electricity sector by 2030. One strategy being considered to achieve this target is the implementation of coconut (copra) oil-based electricity generation, replacing diesel-powered energy generation.
- Targets for the transport sector include:
  - Improving land and marine transport efficiency by 10% by 2030.
  - Reaching 10% of buses being electric by 2030.
  - Reaching 10% of government cars being electric by 2030.
  - Blending of biofuels into diesel (20% by 2030).
- The use of fuel wood, diesel, and gasoline are to be substituted by solar, wind, hydro, coconut oil, biogas, and biomass.
- Waste-to-energy plants are to be built, in order to reduce GHG emissions from landfill.
- Biogas plants for commercial and residential use are to be built (1000 by 2030).
- Vanuatu notes in their NDC that these targets and commitments rely heavily on finance, action, support, technology and capacity development. This conditional cost is estimated at USD $1.2 B.

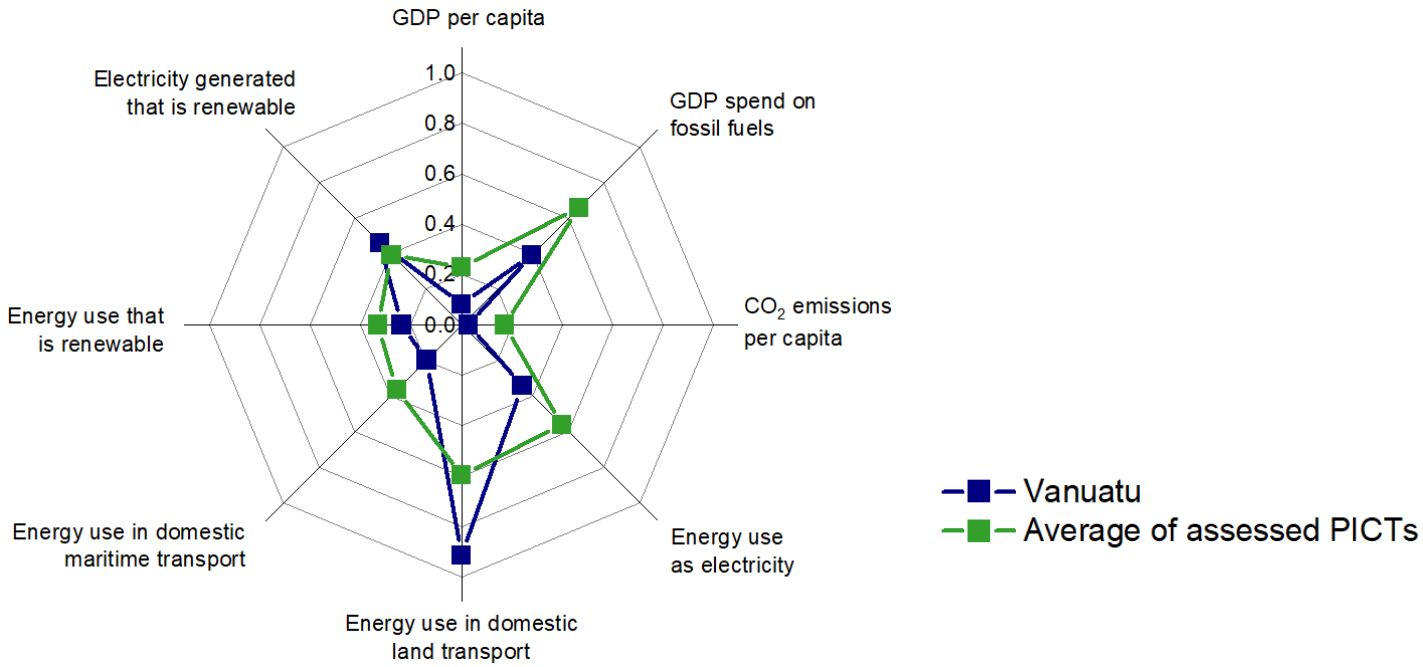
Figure 5. Hydropower is a growing renewable energy source in Vanuatu. Recently the Government of Japan has formalised funding to support construction of the Santo Hydropower project and expansion of the Sarkata Hydro power facility.

Figure 6. Land transport is the largest contributor to emissions in Vanuatu.

Vanuatu's Power to X Potential

Vanuatu is one of the most disaster-prone countries, that will be significantly affected by climate change. Vanuatu has targeted renewable electricity generation by 2030, and has put forwards measures to reduce emissions from the agricultural sector, which is responsible for the majority of emissions. Power to X can assist in decarbonising land transport, which is a significant contributor to emissions.

Competitive Advantage



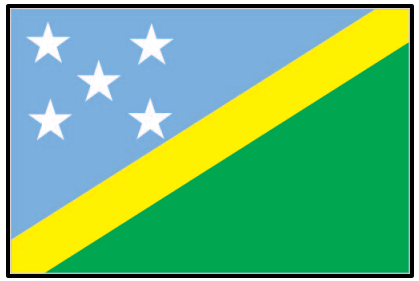
- Vanuatu generates slightly more of its electricity through renewables than the average of the assessed PICTs. The country also spends a relatively low amount of its GDP on fossil fuels, however this is partly due to the large proportion of the energy supply from biomass, as well as the largely rural population.
- Vanuatu has poor solar (lowest of the PICTs) but good wind (5th highest in PICTs) energy potential with up to 67% energy accessibility/coverage.
- Vanuatu can heavily decarbonise through the domestic land transport sector, which is more developed compared to maritime and air transport decarbonisation.

Critical Challenges

- 60% of Vanuatu relies on agriculture for household income and livelihood, much of this is micro-scale subsistence that depends on local rainfall, making the sector extremely vulnerable to climate impacts, loss and damage. For example, Cyclone Pam in 2015 caused losses estimated at 60% of Vanuatu's GDP.
- Vanuatu ranked 8th for climate losses per unit GDP over the 1999–2018 period, whilst The WorldRisk Index 2021 ranks Vanuatu as the world's most vulnerable country to climate and disaster risk based on very high exposure to natural hazards and low coping and adaptative capacities.
- Vanuatu's targets and commitments outlined in the NDC rely heavily on finance, action, support, technology and capacity development. This conditional cost is estimated at USD $1.2 B.
- Key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.

H_2 Case Study:

Solomon Islands



Overview

Population
- 724,000

Gross Domestic Product
- USD $1.6 B
- SBD $13.4 B

Land Area
- 28,896 km^2
- 4% agricultural land
- 79% forested land

Fossil Fuel Consumption
- 1.2 TWh
- 56% of annual energy use

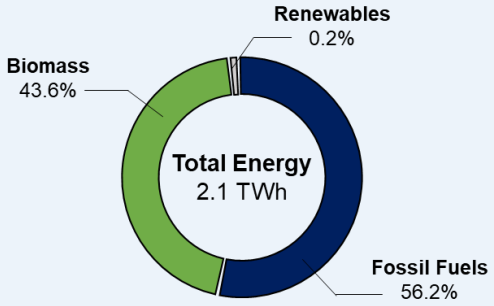
GDP Spent on Fossil Fuel Energy
- 4.2 %
- USD $68 M
- SBD $570 M

CO_2 Emissions
- 0.60 Mt of CO_2e per year
- 0.32 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

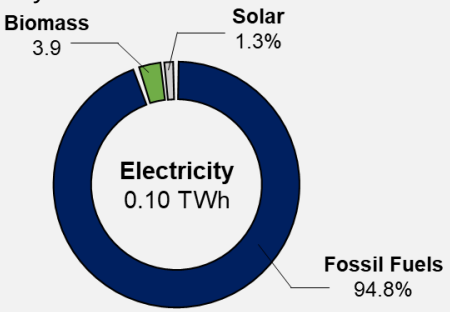
Energy Outlook

- The Solomon Island's annual energy use is around 2.1 TWh, 56% of which is fossil fuel-based.
- The Solomon Islands imports 1.2 TWh of energy as various oils, primarily diesel (equivalent to 0.74 million bbl of diesel).
- Most energy from fossil fuels is used in the land transport sector (53%) and in the generation of electricity (24%).



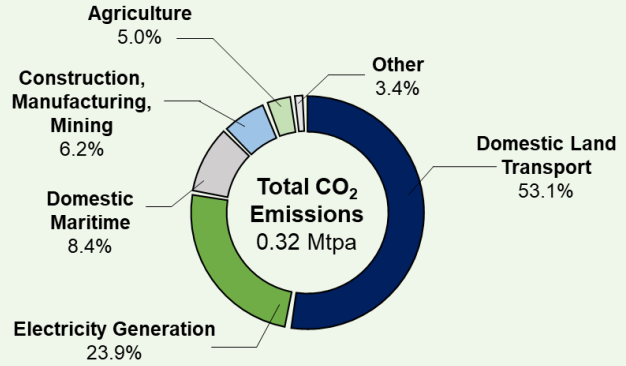
Electricity Mix

- Electricity generation in the Solomon Islands is almost completely fossil fuel-based. The Lungga and Honiara diesel plants are the largest electricity generators, responsible for over 86% of electricity.
- The 1 MW Henderson solar farm contributes to the overall electricity generation, as do rooftop solar systems.
- Energy from the biomass waste created by palm oil production continues is used for electricity generation.
- There are also several community-managed micro-hydro installations.



CO_2 Emissions

- The Solomon Island's total greenhouse gas emissions are 0.60 Mtpa of CO_2e.
- CO_2 emissions total 0.32 Mtpa, whilst the remainder of emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- Over 75% of CO_2 emissions can be attributed to domestic land transport and electricity generation.



Hydrogen Potential

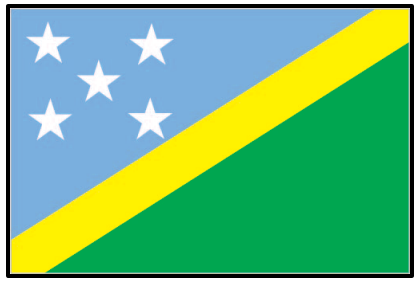
- A significant expense is associated with the fossil fuel use in key sectors, most notably domestic land transport, which costs USD $36 M per year.
- Around 30,000 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	177,000	16.3	1,600	4,100	8,300
Domestic Land Transport	395,000	36.3	3,700	9,300	19,000
Domestic Maritime Transport	62,200	5.7	580	1,500	2,900

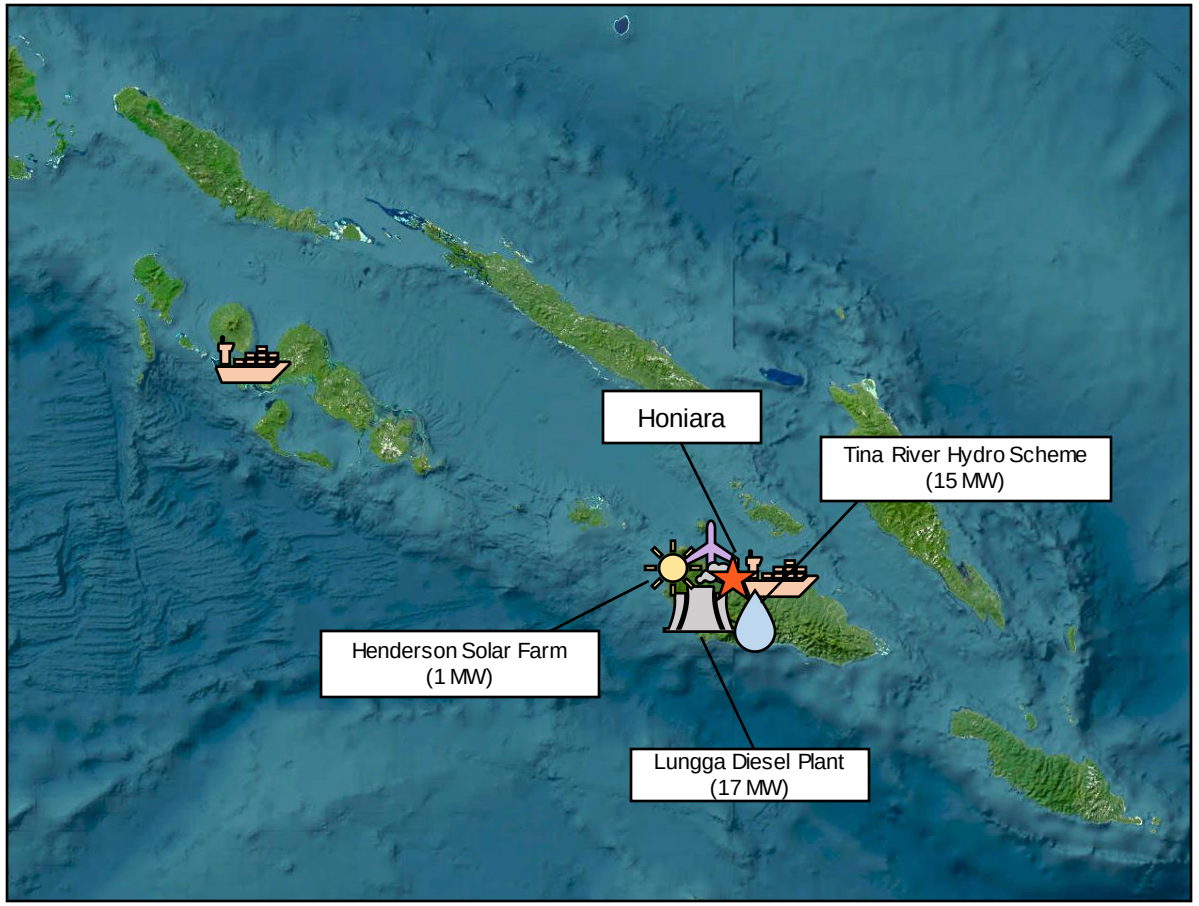
Targets

- The Solomon Islands has a target to achieve net zero emissions by 2050, with appropriate international assistance.
- This includes a target to:
  - Reduce GHG emissions by 14% by 2025 (compared to 2015 levels)
  - Reduce GHG emissions by 33% by 2030 (compared to 2015 levels)
- It is noted that with international assistance, further reductions can be achieved.
- 100% access to electricity is targeted by 2050.

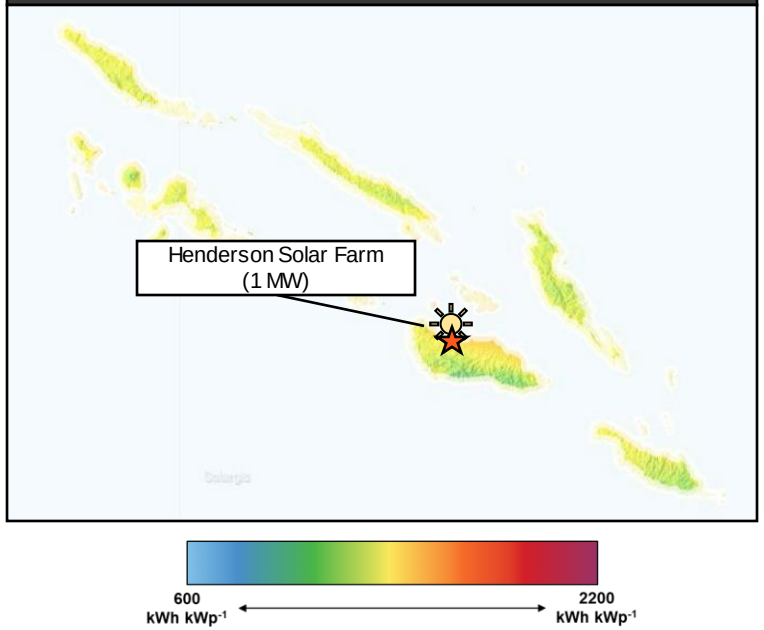


Legend

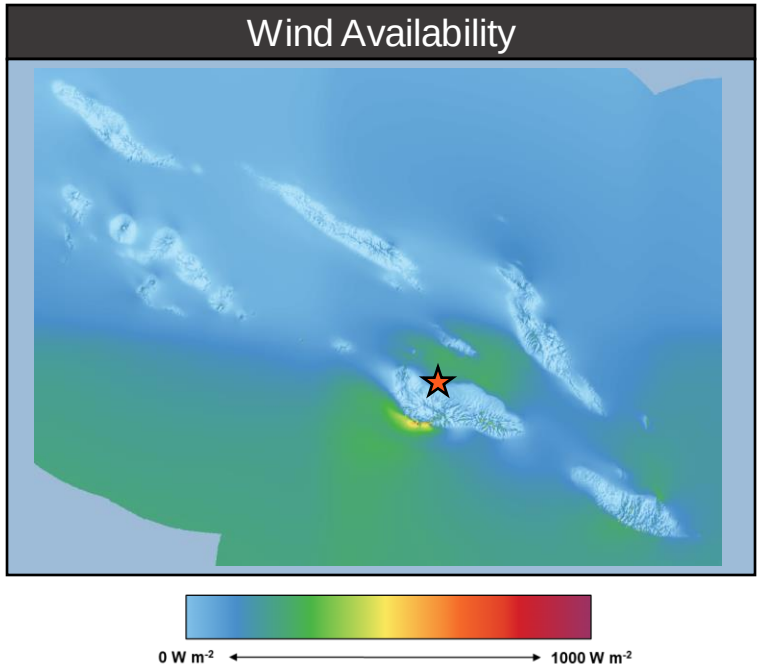
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



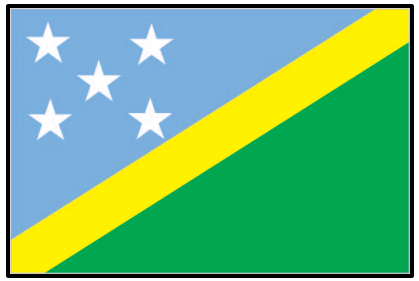
Population

- The Solomon Islands consists of over 1,000 islands, around 350 of which are populated.
- There are six main islands: Guadalcanal, Malaita, Makira, Santa Isabel, Choiseul and New Georgia.
- The population of the capital and largest city, Honiara, is around 67,000, whilst no other city has a population higher than 10,000.

Renewable Energy Potential

- The solar energy potential of the Solomon Islands is good, as evidenced by the recent installation of 2 MW of solar farms at Kirakira, Lata, Malu'u, Munda, and Tulagi, as well as the use of rooftop solar systems.
- The wind potential of the Solomon Islands is extremely low (the lowest of the assessed PICTs).

- The production of 30,000 tpa of hydrogen would require around:
  - 1.5 TWh/yr of electricity
  - 170 MW of electrolyser capacity
  - 0.90 GL/yr of water



Solomon Island's Power to X Potential

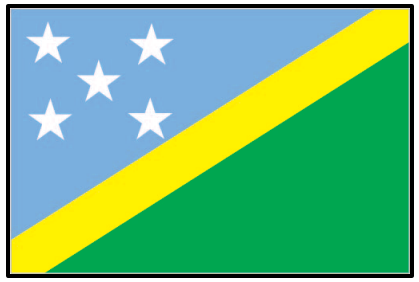
The Solomon Islands spends a significant amount of its GDP on imported fossil fuels, which is increasingly putting stress on the local economy. Nevertheless, these fuels are the backbone of the country's energy supply, therefore a shift to Power to X can assist in enabling a self-sustained renewable energy driven future.

Existing Targets and Strategies for Decarbonisation

- The Solomon Islands have committed to reducing their emissions by 14% by 2025 (compared to 2015 levels), with a 41% reduction in GHG emissions by 2025 achievable pending international assistance to access financial and technical resources.
- Similarly, an emissions reduction of 33% by 2030 (compared to 2015 levels) is targeted, with a 78% reduction in GHGs by 2030 achievable pending international assistance to access financial and technical resources.
- With appropriate international assistance, Solomon Islands can achieve net zero emissions by 2050.
- The sectors targeted are electricity generation (39%) and domestic land and maritime transport (61%).
- The Solomon Islands also intends to use the market and non-market mechanisms under Article 6 of the Paris Agreement.
- The reduction of GHGs is targeted primarily through the development of renewable energy projects, focused on solar and hydropower generation:
  - 23 MW of power is to be produced from 14 solar hybrid systems, three grid-connected solar systems, and one hydropower station.
  - Currently mini hydro schemes across the Solomon Islands total a capacity of around ~400 kW. A large-scale hydroelectricity plant is being developed at the Tina River outside Honiara. With a capacity of 15 MW, the plant could provide 65% of Honiara's electricity demand.
  - A range of hydro and solar plants are also in the feasibility and prefeasibility stages of development.
  - The potential of geothermal energy is also being considered.

Figure 7. The Lungga power station in Honiara. Diesel is responsible for 95% of electricity generation.

Figure 8. The 1 MW solar farm at Henderson.



Solomon Island's Power to X Potential

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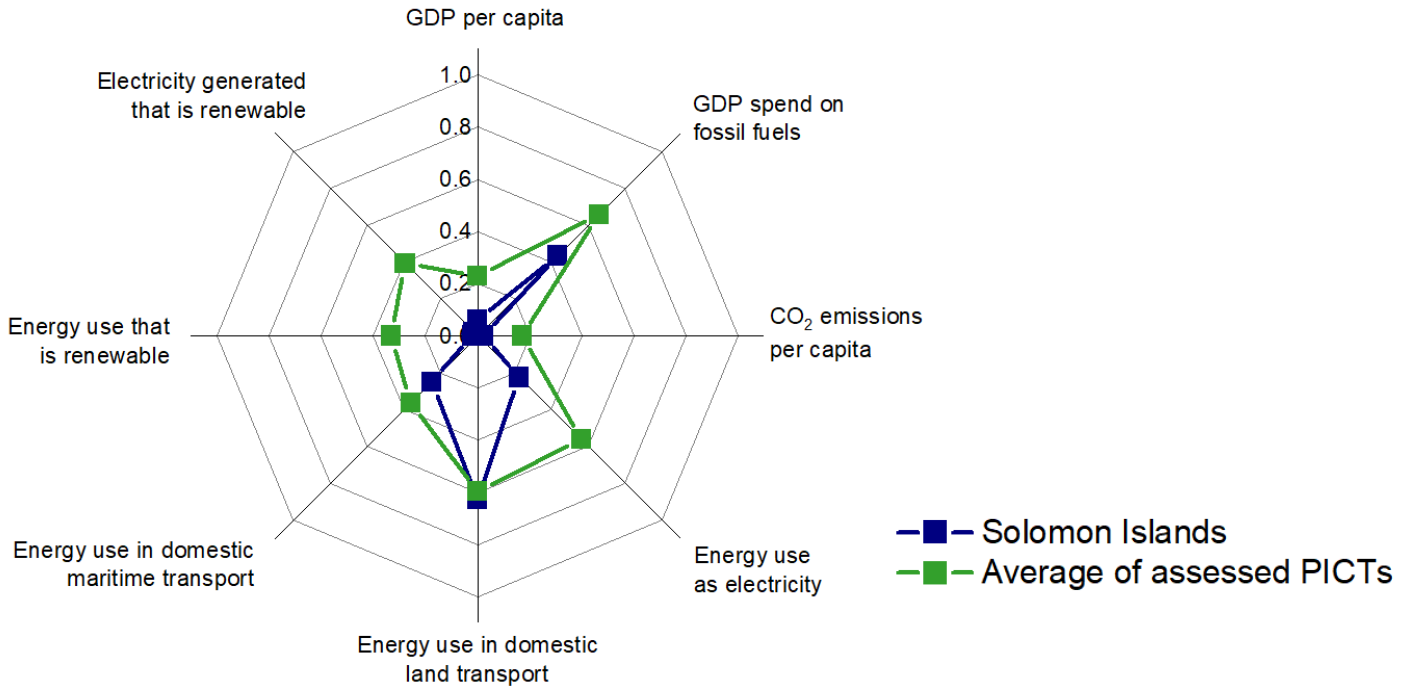
Competitive Advantage



- The Solomon Islands spends a relatively low proportion of GDP on fossil fuels compared to the assessed PICTs, however the country is still heavily exposed to volatile oil prices.
- The Solomon Islands has acceptable solar (8th highest in PICTs) but low wind (lowest of the PICTs) energy potential with up to 73% energy accessibility/coverage.
- The present challenge of low renewable energy penetration in the Solomon Islands provides an advantage for Power to X, as its deployment can support both renewable energy growth as well as decarbonisation of the end use sectors.

Critical Challenges

- The Solomon Islands is ranked 2nd on the World Risk Index for climate risk, and generally experience an average of two cyclones per year, with southern and eastern provinces especially vulnerable.
- It is geographically spread out, with around 80% of the national population live in low-lying coastal areas. This also affects access to affordable energy, as the islands are separated by large areas of sea and with small, isolated communities. The electricity tariff is the most expensive among the PICTs.
- The implementation of renewable power generation facilities faces issues including:
  - Dispersed population and limited infrastructure.
  - A lack of enabling environments to foster private investment in the electricity sector.
  - The need to improve funding opportunities.
- Key challenges for decarbonisation include:
  - An upper range net zero target for 2050 that is contingent upon significant support.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.

H_2 Case Study:

Papua New Guinea

Overview

Population
- 10,143,000

Gross Domestic Product
- USD $31 B
- PGK $112 B

Land Area
- 462,840 km^2
- 3% agricultural land
- 63% forested land

Fossil Fuel Consumption
- 30.5 TWh
- 56% of annual energy use

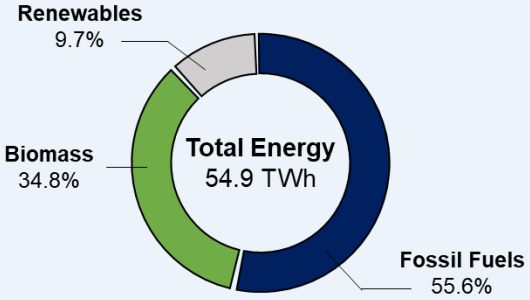
GDP Spent on Fossil Fuel Energy
- 5.8 %*
- USD $1.8 B
- PGK $6.4 B

CO_2 Emissions
- 21.3 Mt of CO_2e per year
- 8.5 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

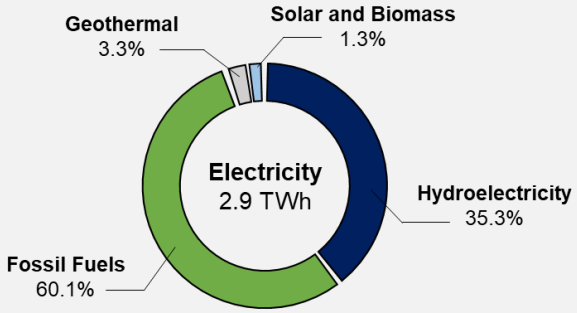
Energy Outlook

- PNG's annual energy use is around 55 TWh, 56% of which is fossil fuel-based.
- PNG's total energy supply from fossil fuels is around 30.5 TWh, which includes imports, as well as produced gas and crude oil.
- Most energy from fossil fuels is used in the generation of electricity (33%), as well as in industry (22%).



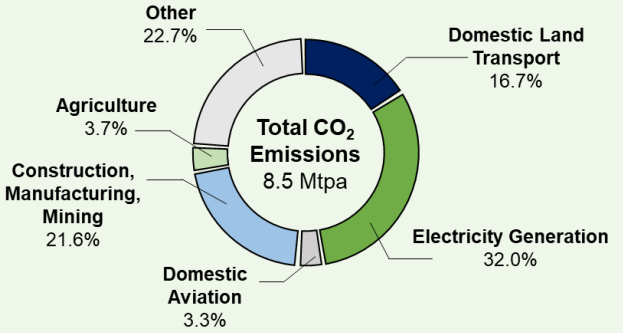
Electricity Mix

- Electricity generation in PNG is provided primarily by hydroelectricity, fuel oil, and diesel, totalling over 95% of generation.
- PNG has 230 MW of hydroelectricity plants, with a further 136 MW under development.
- There are 83 MW worth of gas-fired power plants connected to the Port Moresby grid.
- There is also a 50 MW geothermal plant on Lihir Island.



CO_2 Emissions

- Papua New Guinea's total greenhouse gas emissions are 21.3 Mtpa of CO_2e.
- CO_2 emissions total 8.5 Mtpa, whilst the remainder of emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- Around 50% of emissions result from transport and electricity generation, whilst industry accounts for a significant proportion compared to other PICTs.



Hydrogen Potential

- A significant expense is associated with the fossil fuel use in key sectors, most notably electricity generation, which costs USD $590 M per year.
- Around 480,000 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

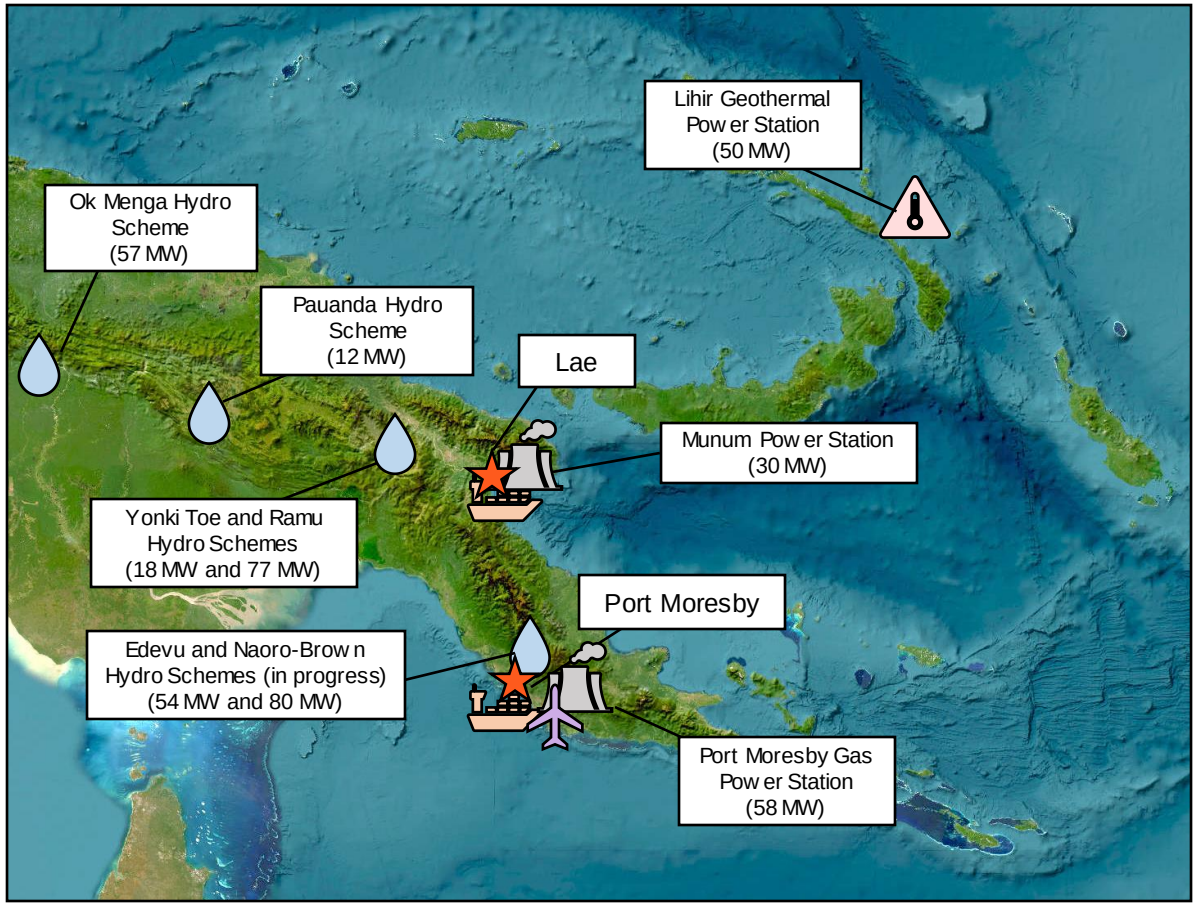
Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	6,370,000	586.3	60,000	150,000	300,000
Domestic Land Transport	3,310,000	304.8	31,000	78,000	16,000
Domestic Air Transport	658,000	60.6	6,200	15,000	31,000

Targets

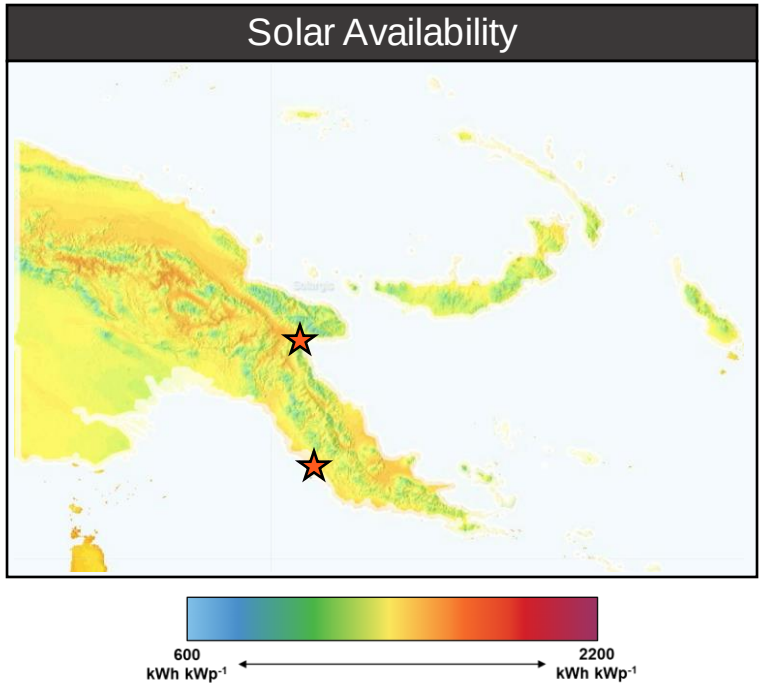
- PNG is targeting carbon neutrality within the energy industries sub-sector by:
  - Increasing the share of installed capacity of renewable energy from 30% in 2015 to 78% in 2030.
  - Reducing energy demand.
  - Establishing a framework for fossil fuel emission offsetting.
- PNG is targeting net zero emissions by 2050 through the Climate Ambition Alliance.

Legend

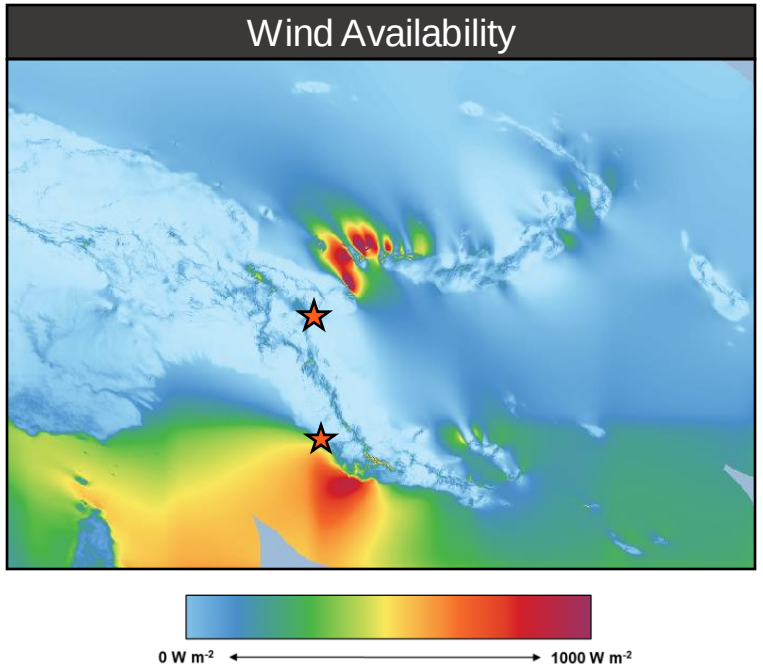
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



Population

- PNG consists of around 600 islands, although most of the population lives on the main land mass.
- The capital and largest city is Port Moresby, with a population of around 400,000.
- Over 85% of the population live in rural areas, and around 12% in urban areas.

Renewable Energy Potential

- PNG has good solar energy potential, with large areas of the country experiencing a high average solar energy availability. Unlike some other PICTs, there is significant land availability.
- PNG experiences very poor wind energy on land, whilst high wind energy is seen at a few coastal regions to the north and south of the main land mass.

- The production of 480,000 tpa of hydrogen would require around:

24.5 TWh/yr of electricity

2800 MW of electrolyser capacity

14.6 GL/yr of water

Papua New Guinea's Power to X Potential

PNG generates a considerable amount of energy through renewables, compared to other PICTs. However, the terrain and isolated communities cause difficulties in achieving electricity access, healthcare, and education. A shift to Power to X can assist enable energy security, especially in industry, heavy transport, and aviation. PNG has the potential to become a supplier of renewable fuels to the Pacific.

Existing Targets and Strategies for Decarbonisation

- PNG is committing to a target of carbon neutrality within the energy industries sub-sector. This will be achieved by:
  - Increasing the installed capacity of renewables from 30% in 2015 to 78% in 2030 for on-grid connection managed by PNG Power Limited. This goal was downgraded from 100% due to the lag time of large generation projects, as well as the expanding LNG sector.
  - Reducing energy demand through adoption and implementation of Minimum Energy Performance Standards and Labelling (MEPSL) Regulations as well as enhancing public awareness of energy use and means of reducing energy use.
  - Establishing a framework for fossil fuel emission offsetting. It is noted that a full transition will take time given PNG's complex geographies and dispersed population as well as a growing economy.
  - Within the transport subsector, measures to reduce emissions could include (i) encouraging the introduction of fuel-efficient transport equipment, (ii) encouraging sustainable substitution of fossil fuels with biofuels, and (iii) encouraging the introduction of hybrid and electric vehicles. These measures will need financial and technical support.
- It is targeted to turn the LULUCF sub-sector back from a carbon source to a carbon sink, by reducing the annual emission from deforestation and forest degradation due to agriculture expansion and commercial logging by 10,000 Gg CO_2e. This will be achieved by:
  - A 25% reduction in both the area of annual deforestation and annual degradation against 2015 levels .
  - An increase in the areas of forest planted.

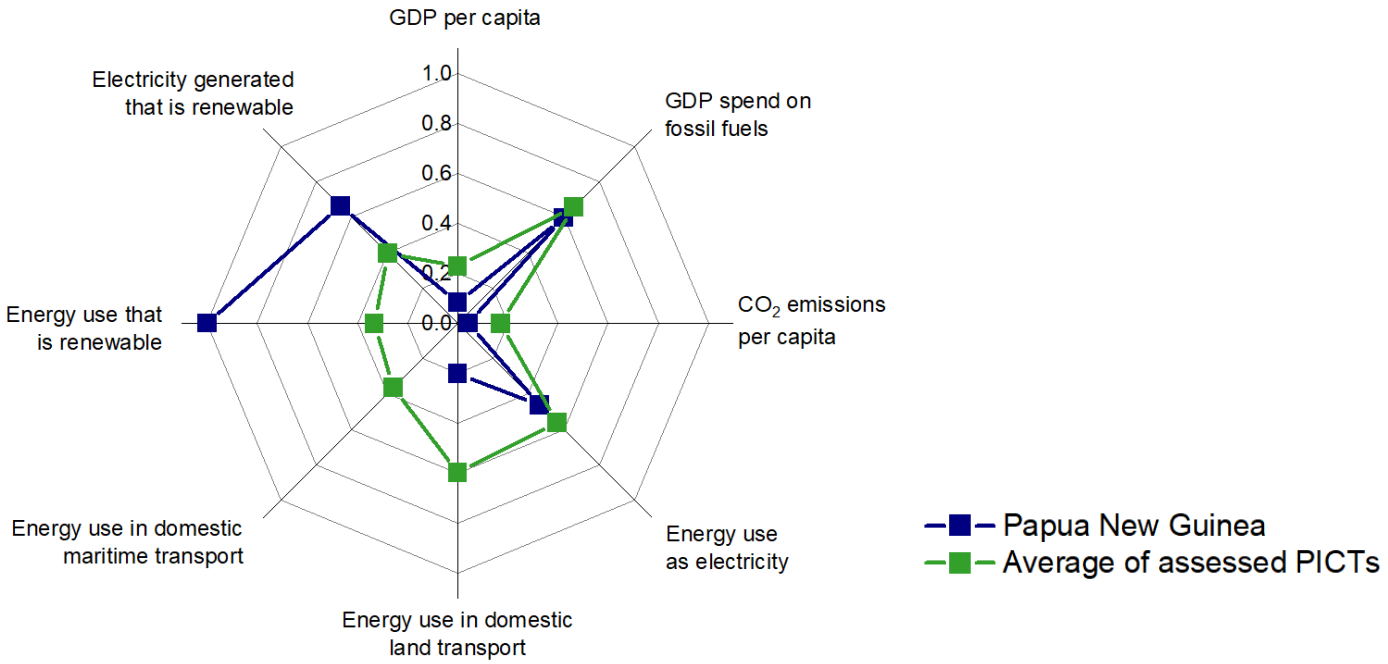
Figure 9. The recently-constructed Edevu hydro power plant (54 MW).

Figure 10. The Lihir geothermal power station (50 MW).

Papua New Guinea's Power to X Potential

PNG generates a considerable amount of energy through renewables, compared to other PICTs. However, the terrain and isolated communities cause difficulties in achieving electricity access, healthcare, and education. A shift to Power to X can assist enable energy security, especially in industry, heavy transport, and aviation. PNG has the potential to become a supplier of renewable fuels to the Pacific.

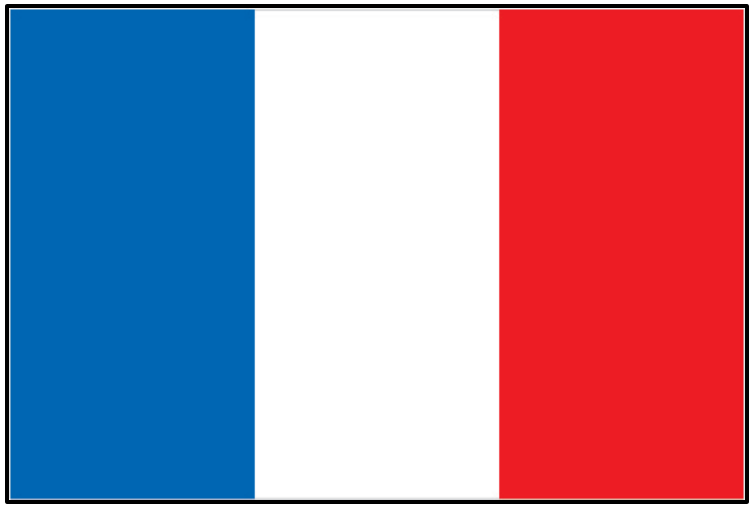
Competitive Advantage



- Papua New Guinea generates a large portion of its electricity use through renewables, particularly through hydroelectric and geothermal energy. There is also strong potential for large-scale solar and offshore wind energy.
- PNG has acceptable solar (8th highest in PICTs) but low wind (12th highest in PICTs) energy potential with up to 60% energy accessibility/coverage.
- PNG has the potential for a strong foundation for Power to X and for the country to become a climate leader and source of knowledge in the Pacific, as well as an exporter of clean fuels in the Pacific.

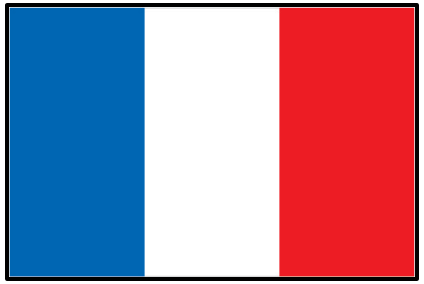
Critical Challenges

- Papua New Guinea has around 5-7% of the world's biodiversity in less than 1% of the world's land mass, as well as the 3rd largest pristine rainforest in the world. This biodiversity is at considerable risk of climate change.
- PNG is ranked as the 10th most vulnerable country in the world to the risk of climate change. PNG's highlands region is susceptible to extreme weather such as heavy rainfall, which may increase the occurrence of landslides and inland flooding. The coastal regions, the islands and the low-lying atoll areas are mostly vulnerable to extreme weather events, storm surge, sea-level rise, and coastal inundation.
- The population is mostly rural, with less than 20% having access to grid electricity, and limited access to health care, education, and broader development opportunities.
- PNG depends on large reserves of natural gas as an export opportunity.
- Key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.



H_2 Case Study:

New Caledonia



Overview

Population
- 277,000

Gross Domestic Product
- USD $10 B
- XPF $1,116 B

Land Area
- 18,575 km^2
- 10% agricultural land
- 46% forested land

Fossil Fuel Consumption
- 16.9 TWh
- 97% of annual energy use

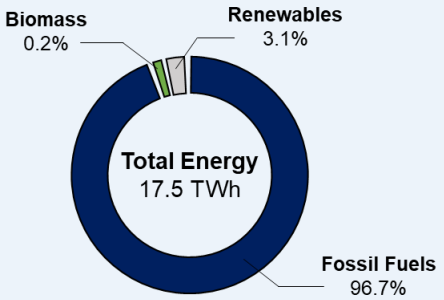
GDP Spent on Fossil Fuel Energy
- 9.6 %
- USD $0.97 B
- XPF $108 B

CO_2 Emissions
- 5.5 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

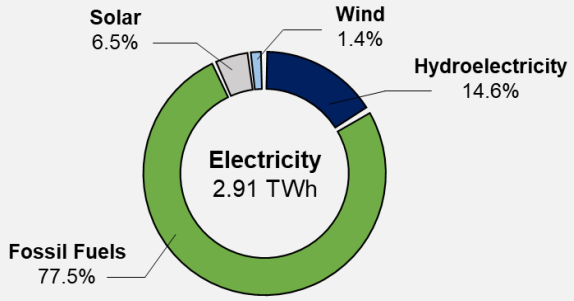
Energy Outlook

- New Caledonia's annual energy use is around 18 TWh, 97% of which is fossil fuel-based.
- New Caledonia's total energy supply from fossil fuels is around 17 TWh, which mostly includes imports of oils such as diesel, and coal.
- Most energy from fossil fuels is used in the generation of electricity (56%), as well as in industry (20%).



Electricity Mix

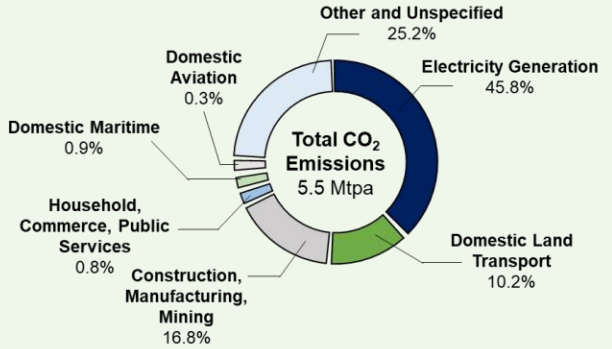
- Electricity generation in New Caledonia is provided primarily by fossil fuels and hydroelectricity, totalling over 90% of generation.
- The bulk of electricity is produced by the coal-fired power plants at the Prony and Koniambio Nickel (KNS) refineries, and the heavy fuel power plant at Société le Nickel (SLN) in Noumea.



CO_2 Emissions

- New Caledonia's estimated CO_2 emissions are 5.5 Mtpa, whilst other GHG emissions are mainly generated by waste and agriculture
- Over 60% of CO_2 emissions are related to electricity generation and use in industry, and it is likely that unspecified emissions may also fall into these main sectors.

Note: Other and unspecified may include emissions relating to transport, electricity generation, and commercial and industrial use.



Hydrogen Potential

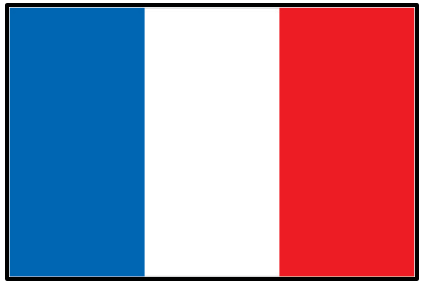
- A significant expense is associated with the fossil fuel use in key sectors, most notably electricity generation and land transport, which costs USD $540 M per year.
- Around 345,000 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	5,890,000	542.1	550,000	140,000	280,000
Domestic Land Transport	1,317,000	121.1	12,000	31,000	62,000
Domestic Maritime Transport	116,000	10.6	1,100	2,700	5,400

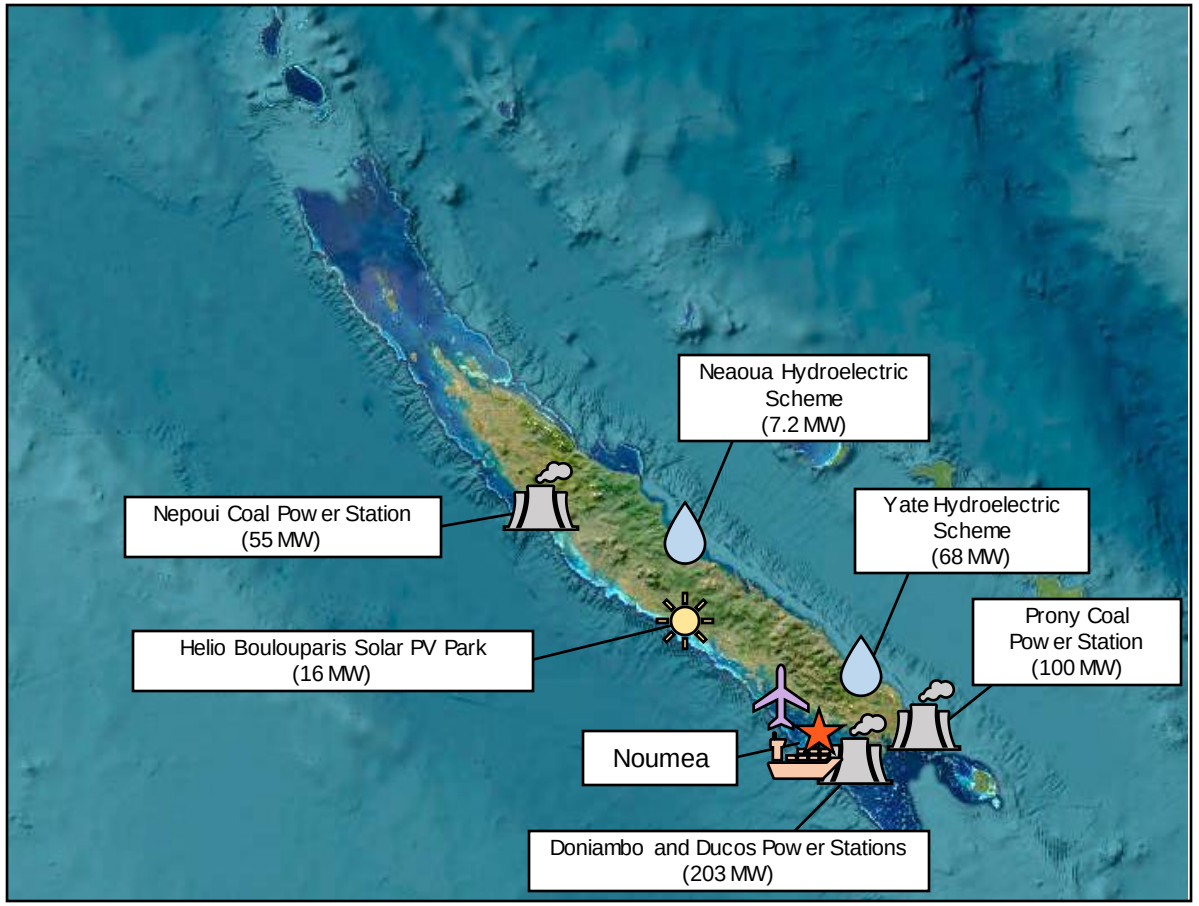
Targets

- New Caledonia is targeting the following energy-related emissions reductions by 2030, in the NDC submitted by France:
  - 35% reduction in emissions in the residential and tertiary sectors.
  - 10% reduction in emissions in the mining and metallurgy sector.
  - 15% reduction in emissions in the transport sector.
- France is also targeting net zero emissions by 2050 through the Climate Ambition Alliance.

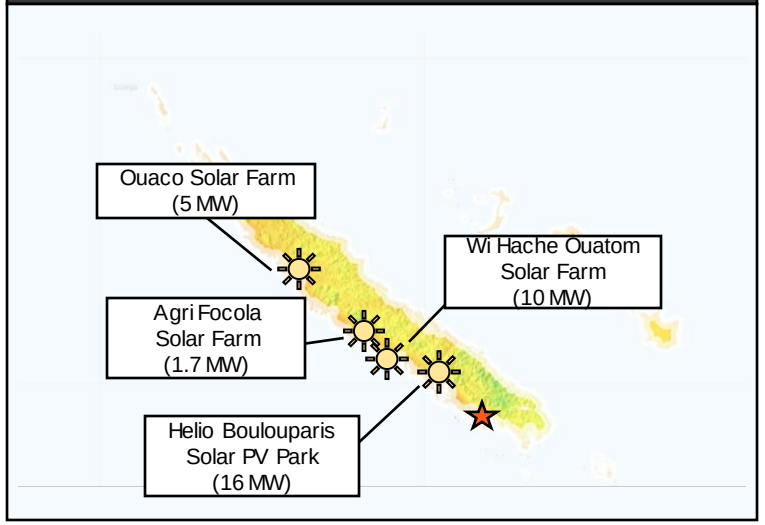


Legend

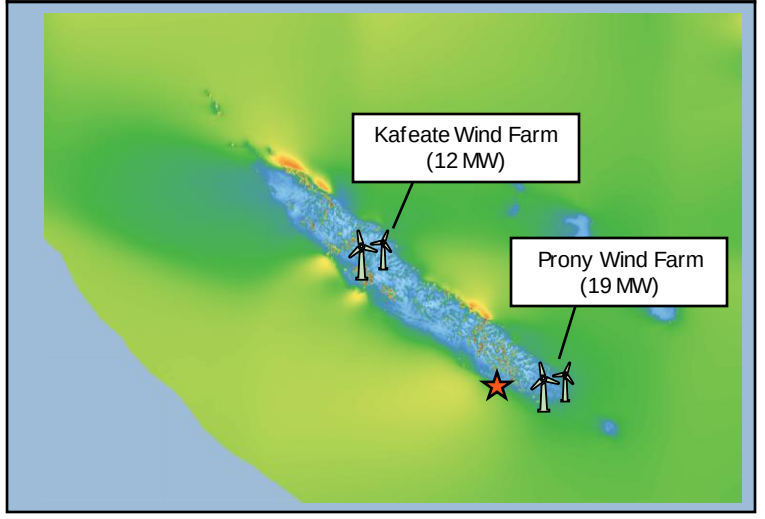
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



Population

- New Caledonia consists of the main islands of Grand Terre, Ouvéa, Tiga, Maré and Lifou, as well as around 140 total islands.
- The capital and largest city is Noumea on Grand Terre, with a population of around 100,000.
- Around 90% of the total population lives on Grand Terre.

Renewable Energy Potential

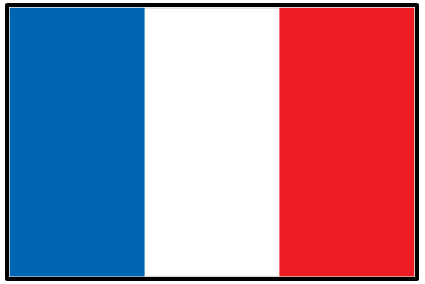
- New Caledonia has good solar energy potential, with large areas experiencing a fairly high average solar energy availability. A large 16 MW solar PV farm is located on Grand Terre.
- New Caledonia experiences strong wind potential in certain areas of Grand Terre, particularly around the coasts.

- The production of 345,000 tpa of hydrogen would require around:

17.3 TWh/yr of electricity

2000 MW of electrolyser capacity

10.4 GL/yr of water



New Caledonia's Power to X Potential

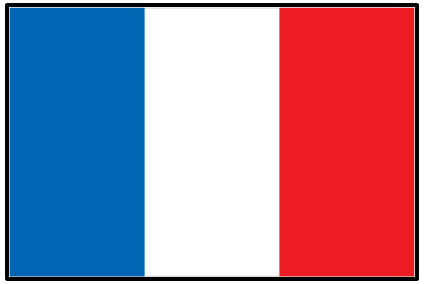
New Caledonia spends a significant amount of its GDP on imported fossil fuels, which is increasingly putting stress on the local economy. These fuels are the backbone of the territory's economy, through the Ni mining industry, which is hindering efforts to decarbonise. A shift to Power to X can assist in enabling a self-sustained renewable energy driven future.

Existing Targets and Strategies for Decarbonisation

- In the first NDC submitted by France on behalf of New Caledonia, the following emissions reductions are targeted by 2030, in relation to a 2010 baseline level:
  - 35% reduction in emissions in the residential and tertiary sectors.
  - 10% reduction in emissions in the mining and metallurgy sector.
  - 15% reduction in emissions in the transport sector.
- These sectors cover around 70% of GHG emissions.
- In addition to these targets, New Caledonia adopted the Energetic Transition Scheme of New Caledonia (STENC) in June 2016. The scheme has three main objectives for 2030:
  - Reduction of the energy consumption by 20% for primary energy and 25% for final consumption.
  - Reduction of the CO_2 emissions by 35% in the residential and tertiary sector, 10% in mining and metallurgy, 15% in the transport sector.
  - Development of renewable energies to reach 100% of the consumption of the public distribution of electrical energy and 100% of electrical energy on the smaller islands of the archipelago.
- Plans for renewables implementation include expanding capacity of hydroelectricity (to ~150 MW), wind (to ~70 MW), and solar PV (to ~120 MW, 63 MW with storage).

Figure 11. The Yate Dam (68 MW).

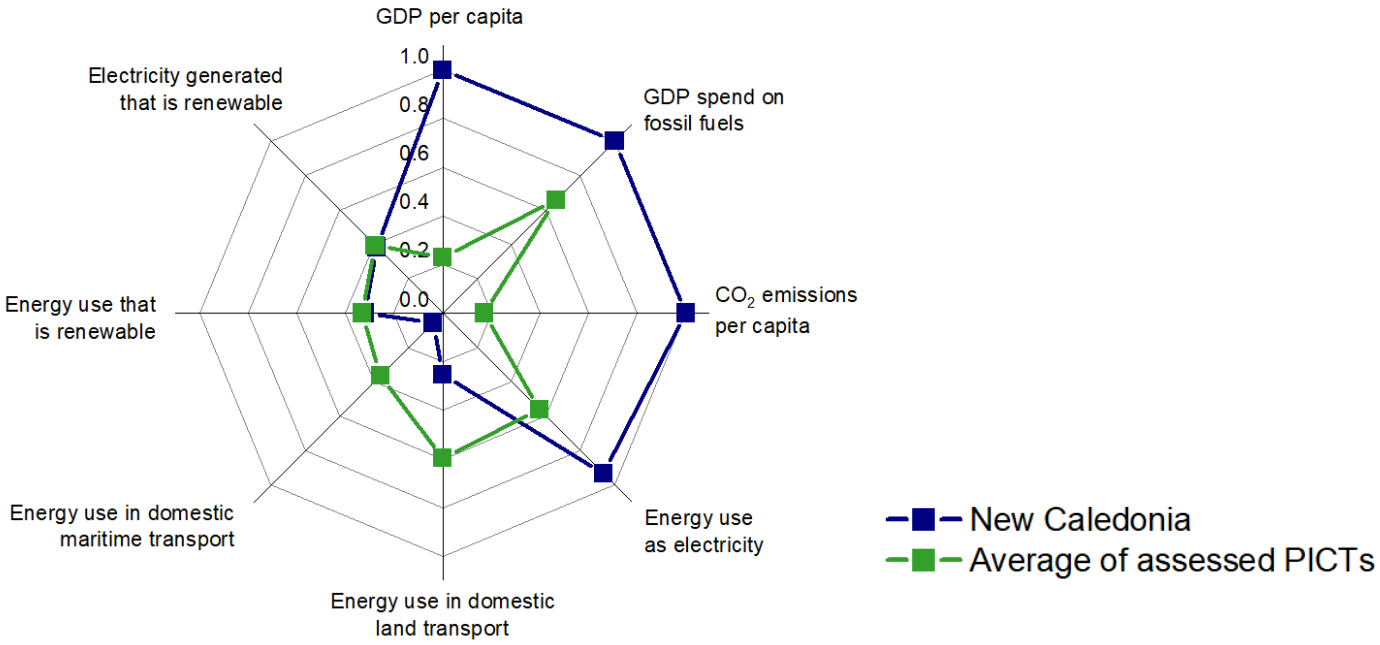
Figure 12. The Helio Boulouparis 2 Solar Park (16 MW, 10 MWh ESS).



New Caledonia's Power to X Potential

New Caledonia spends a significant amount of its GDP on imported fossil fuels, which is increasingly putting stress on the local economy. These fuels are the backbone of the territory's economy, through the Ni mining industry, which is hindering efforts to decarbonise. A shift to Power to X can assist in enabling a self-sustained renewable energy driven future.

Competitive Advantage



- New Caledonia's emissions per capita are higher than all assessed PICTs, and much of the world. The territory holds between 20% and 30% of the world's known nickel reserves, with Ni refining representing 75-80% of New Caledonia's energy consumption.
- New Caledonia has acceptable solar (8th highest in PICTs) and wind (5th highest in PICTs) energy potential with up to 100% energy accessibility/coverage.
- Power to X can assist in decarbonising the Ni industry, without which New Caledonia cannot achieve any ambitious decarbonisation targets.

Critical Challenges

- Climate change is impacting New Caledonia's agricultural sector. Farmers face challenges as temperatures rise and rainfall becomes less predictable, including declining crop yields, increased production costs, and natural disaster risks.
- The current targets for reduction of emissions are not ambitious enough to make a significant dent in the total emissions. The 10% emissions reduction target in the mining and metallurgy sector is low, as this sector is responsible for over 70% of energy use.
- The implementation of large-scale renewables is challenged by the variability in solar, wind, and water resources, and the difficulty of storage.
- Key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.
  - Aging energy infrastructure.

H_2 Case Study:

Kiribati

Overview

Population
- 131,000

Gross Domestic Product
- USD $0.22 B
- AUD $0.34 B

Land Area
- 811 km^2
- 15% agricultural land
- 43% forested land

Fossil Fuel Consumption
- 0.28 TWh
- 63% of annual energy use

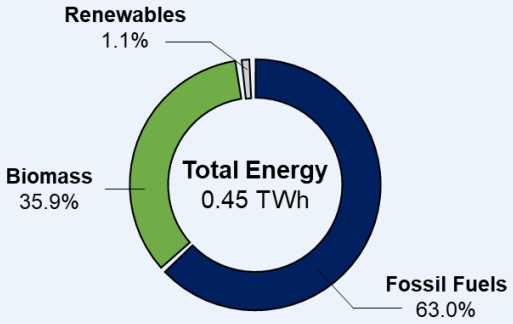
GDP Spent on Fossil Fuel Energy
- 7.4 %
- USD $16 M
- AUD $24 M

CO_2 Emissions
- 116 kt of CO_2e per year
- 77.1 kt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

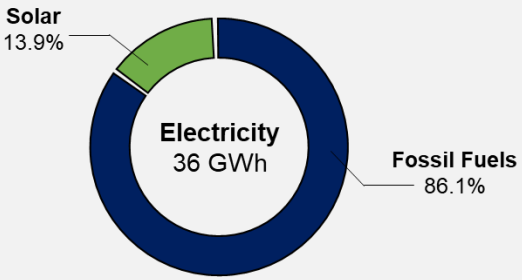
Energy Outlook

- Kiribati's annual energy use is around 0.45 TWh, 63% of which is fossil fuel-based.
- Kiribati imports 0.28 TWh of energy as various oils, primarily diesel (equivalent to 0.18 million bbl of diesel).
- Around 65% of fossil fuel use is attributed to electricity generation and domestic land transport.



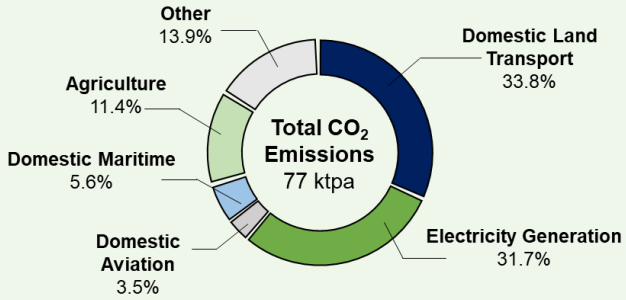
Electricity Mix

- Kiribati produces the vast majority of its electricity from imported fossil fuels (over 86%).
- South Tarawa (responsible for most of electricity consumption) has around 6 MW of diesel generators and around 1.5 MW of ground and roof mounted solar capacity.
- The South Tarawa Renewable Energy Project is expected to generate another 5 MW.



CO_2 Emissions

- Kiribati's total greenhouse gas emissions are 116 ktpa of CO_2e.
- CO_2 emissions total 77 ktpa, whilst the remainder of emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- Over 70% of emissions are attributed to electricity generation (31%) and domestic transport (43%)



Hydrogen Potential

- A significant expense is associated with the fossil fuel use in key sectors, including domestic land transport and electricity generation, which costs USD $10.9 M per year.
- Around 6,300 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

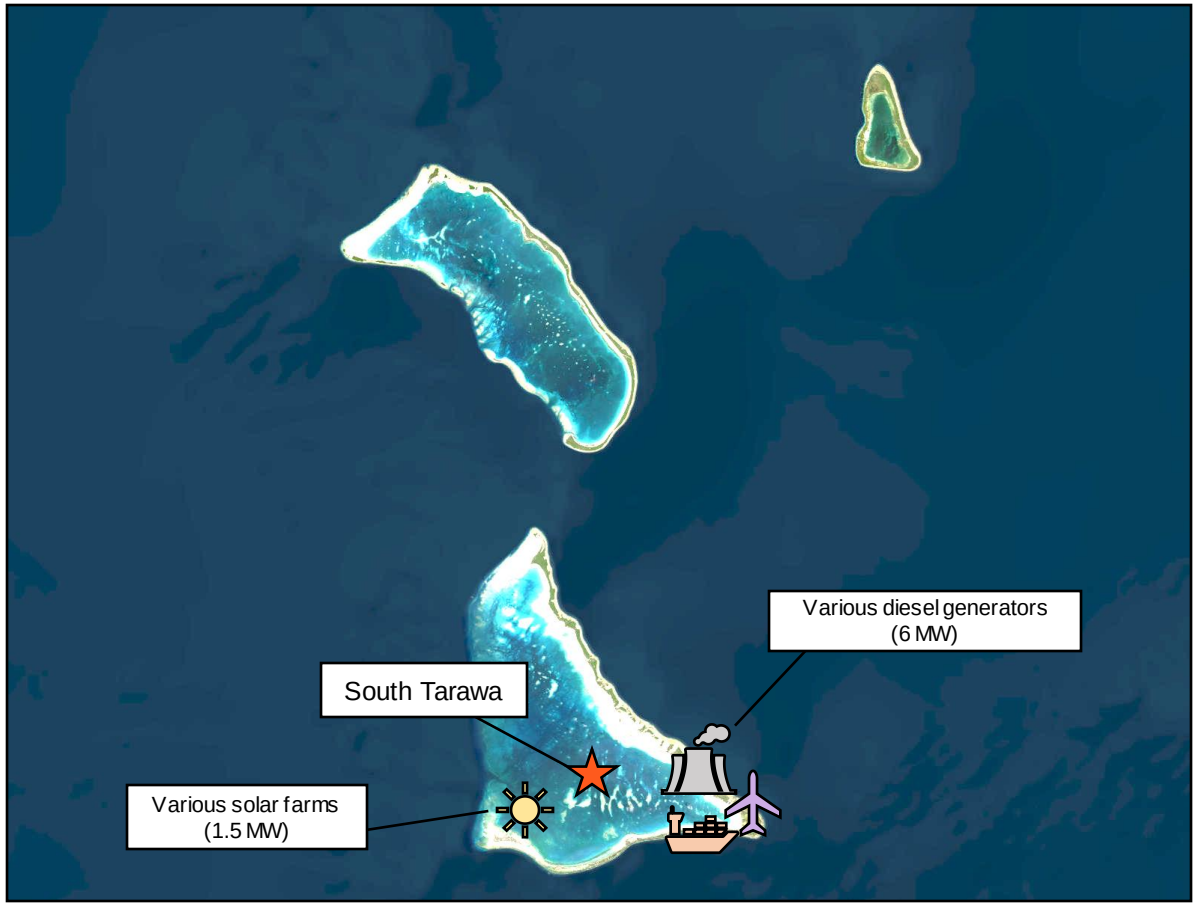
Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	57,000	5.26	530	1,300	2,700
Domestic Land Transport	61,000	5.61	570	1,400	2,900
Domestic Maritime Transport	10,400	0.954	97	240	490

Targets

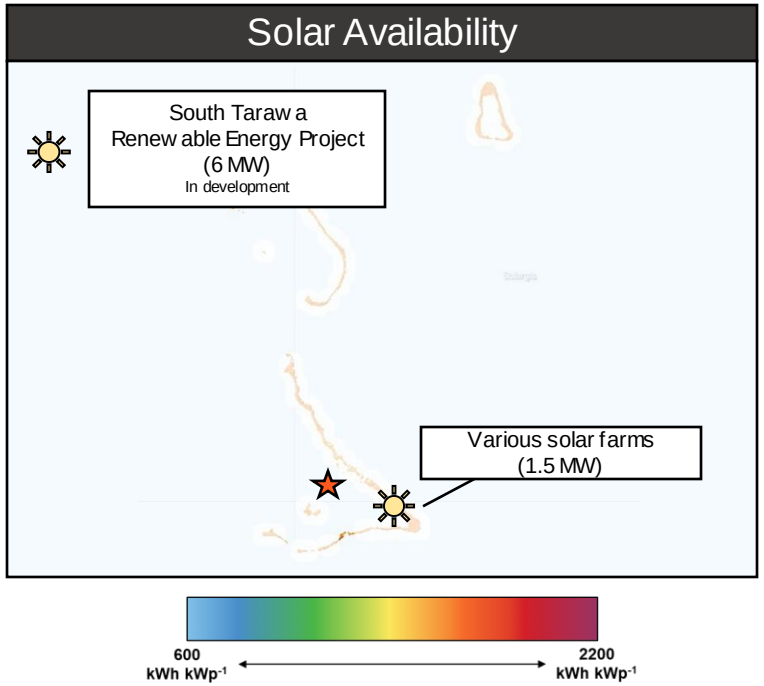
- Kiribati's revised NDC in 2022 includes the key mitigation actions:
  - To reduce GHG emissions by 9.5% and 16.7% by 2025, unconditionally and conditionally, respectively.
  - To reduce GHG emissions by 8.0% and 23.8% by 2030, unconditionally and conditionally, respectively.
- Kiribati is targeting net zero emissions by 2050 through the Climate Ambition Alliance.

Legend

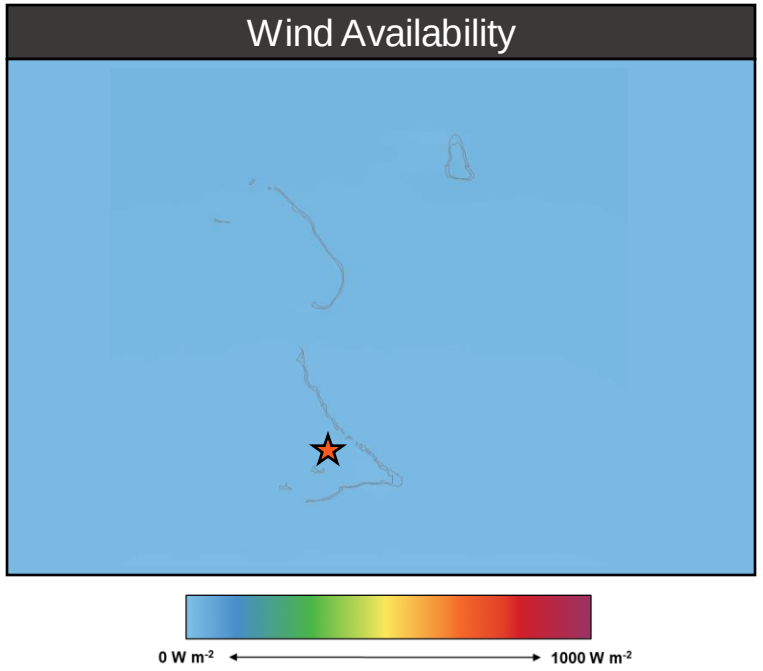
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



Population

- Kiribati is made up of three main island groups, the Gilbert, Phoenix, and Line Islands, as well as one isolated island, spread over a large region and totaling 33 atolls and islands.
- The population of the capital region, South Tarawa, is approximately 68,000, comprising just over half of the total population.

Renewable Energy Potential

- Kiribati has a small land mass, however, the solar availability is very high, ranking amongst the highest of the assessed PICTs.
- The wind availability is poor, ranking amongst the lowest of the assessed PICTs.

- The production of 6,300 tpa of hydrogen would require around:
  - 0.32 TWh/yr of electricity
  - 36 MW of electrolyser capacity
  - 0.19 GL/yr of water

Kiribati's Power to X Potential

Kiribati is highly reliant on fossil fuels for 86% of its energy needs, particularly in the mobility sector and electricity generation. A shift to Power to X can enable energy security, especially in the maritime, heavy transport, and aviation industries. Kiribati also has the highest solar availability of the PICTs, which is leading to the decarbonisation of electricity generation through solar PV projects.

Existing Targets and Strategies for Decarbonisation

- Kiribati is targeting the reduction of GHG emissions by 16.7% by 2025, and by 23.8% by 2030, contingent upon international assistance.
- In power generation, Kiribati is committed to increasing the use of renewable energy. For example, the South Tarawa Renewable Energy Project is developing a ground-based 5 MW Solar PV Plant and a 13 MWh battery energy storage system located at the Bonriki Water Reserve.
- In the transport sector, strategies for reducing emissions in aims for decarbonisation include:
  - Utilisation of more fuel-efficient motors.
  - Use of low-carbon vessels.
  - Shifting to public transportation.
  - Use of biofuels in land and maritime transport.
- Improvements in energy efficiency are focused on energy efficiency in buildings and industry, upgrading of equipment and tools, and retrofitting of major hotels and commercial buildings.
- Emissions from waste are planned to be reduced by the introduction of composting systems to create biological fertiliser for domestic use.
- In the AFOLU sector, the enhancement of mangrove forests can improve their efficiency as a carbon sink.

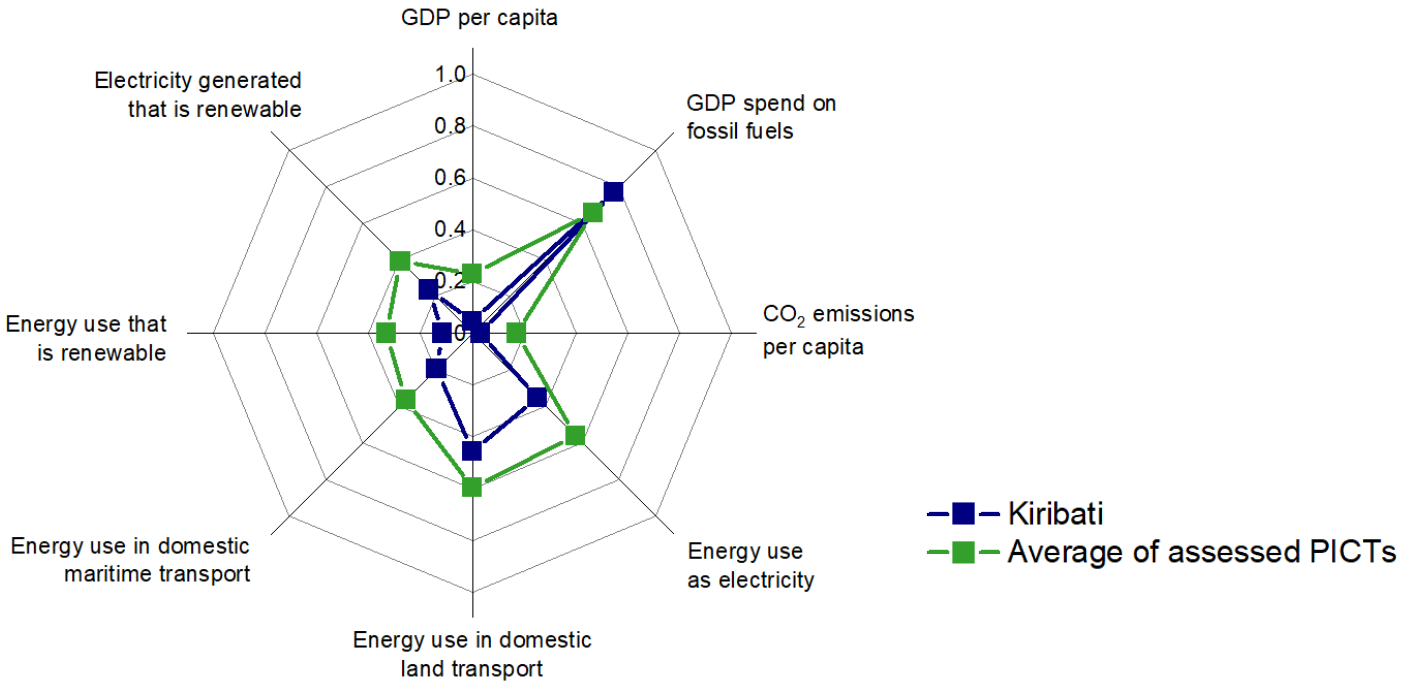
Figure 13. The first 400 kW solar PV system in South Tarawa.

Figure 14. Small ferries are used for transportation between islands.

Kiribati's Power to X Potential

Kiribati is highly reliant on fossil fuels for 86% of its energy needs, particularly in the mobility sector and electricity generation. A shift to Power to X can enable energy security, especially in the maritime, heavy transport, and aviation industries. Kiribati also has the highest solar availability of the PICTs, which is leading to the decarbonisation of electricity generation through solar PV projects.

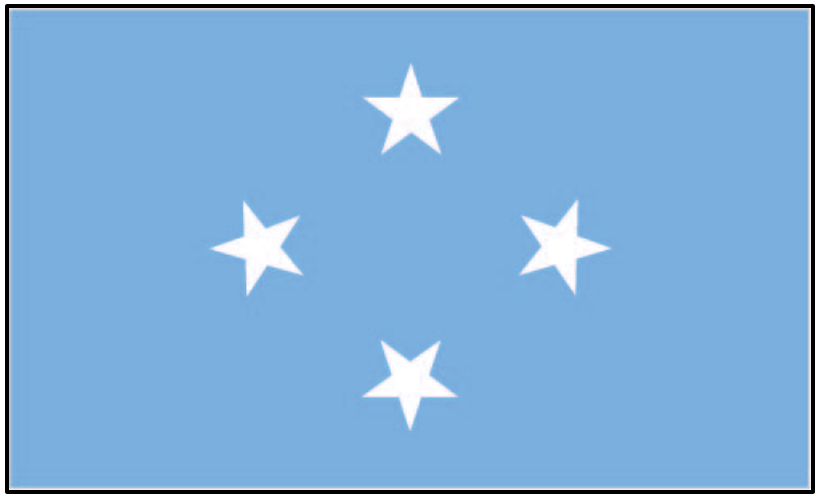
Competitive Advantage



- Kiribati spends a relatively high proportion of its GDP on fossil fuels, which are used for over 85% of electricity generation.
- Kiribati has strong solar (highest of the PICTs) but low wind (12th highest in PICTs) energy potential with up to 92% energy accessibility/coverage.
- Kiribati has the opportunity to significantly decarbonise and decrease reliance on fossil fuels through the implementation of solar energy, whilst Power to X can assist in decarbonising heavy transport sectors.

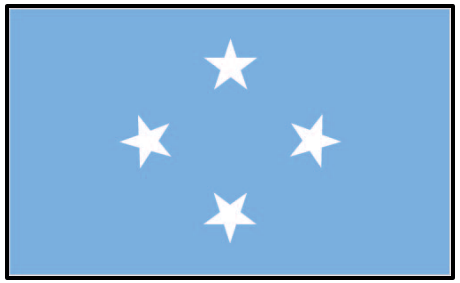
Critical Challenges

- Kiribati is at extreme risk due to climate change (ranking 19th on the World Risk Index), particularly due to its very low elevation, with a maximum elevation only 3-4 m above sea level.
- Other key risks have been identified as heatwaves, ocean acidification, drought, floods, and cyclones.
- Kiribati is currently highly dependent on fossil fuels for energy generation and is thus heavily exposed to volatile oil prices.
- Due to the wide spread of the islands of Kiribati, it is difficult to achieve 100% renewable electricity and net zero long terms targets.
- Key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.



H_2 Case Study:

Federated States of Micronesia



Overview

Population
- 114,000

Gross Domestic Product
- USD $0.43 B

Land Area
- 702 km^2
- 25% agricultural land
- 75% forested land

Fossil Fuel Consumption
- 0.59 TWh
- 98% of annual energy use

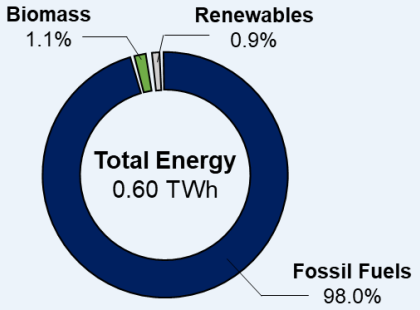
GDP Spent on Fossil Fuel Energy
- 8.0 %
- USD $34 M

CO_2 Emissions
- 0.24 Mt of CO_2e per year
- 0.16 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

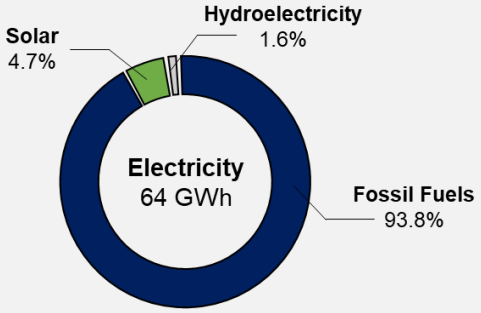
Energy Outlook

- The Federated States of Micronesia's (Micronesia) total energy supply is dominated by fossil fuels, providing 98% of the country's total 0.60 TWh of energy use, equivalent to 0.37 million bbl of diesel.
- Almost 40% of fossil fuels are used in energy generation, with a further 33% used in domestic land transport.



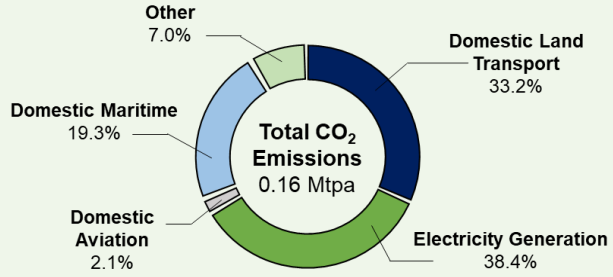
Electricity Mix

- A significant proportion (94%) of Micronesia's electricity is generated from fossil fuels.
- The 600 kW solar plant in Pohnpei is the largest solar project in Micronesia, providing up to 10% of peak electricity demand in Pohnpei. Other 200-350 kW systems have been implemented in each of the four states.
- The 1.8 MW hydro scheme in Pohnpei also contributes to electricity generation when operational.



CO_2 Emissions

- Micronesia's total greenhouse gas emissions are 0.24 Mtpa of CO_2e.
- CO_2 emissions total 0.16 Mtpa, whilst the remainder of emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- Over 90% of CO_2 emissions can be attributed to domestic land and maritime transport, and electricity generation.



Hydrogen Potential

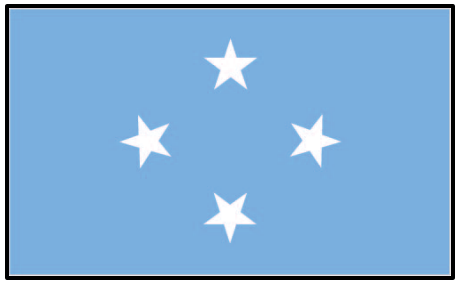
- A significant expense is associated with the fossil fuel use in key sectors, most notably electricity generation, which costs USD $13 M per year.
- Around 16,000 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	143,000	13.1	1,300	3,300	6,700
Domestic Land Transport	123,000	11.3	1,200	2,900	5,800
Domestic Maritime Transport	71,700	6.60	670	1,700	3,400

Targets

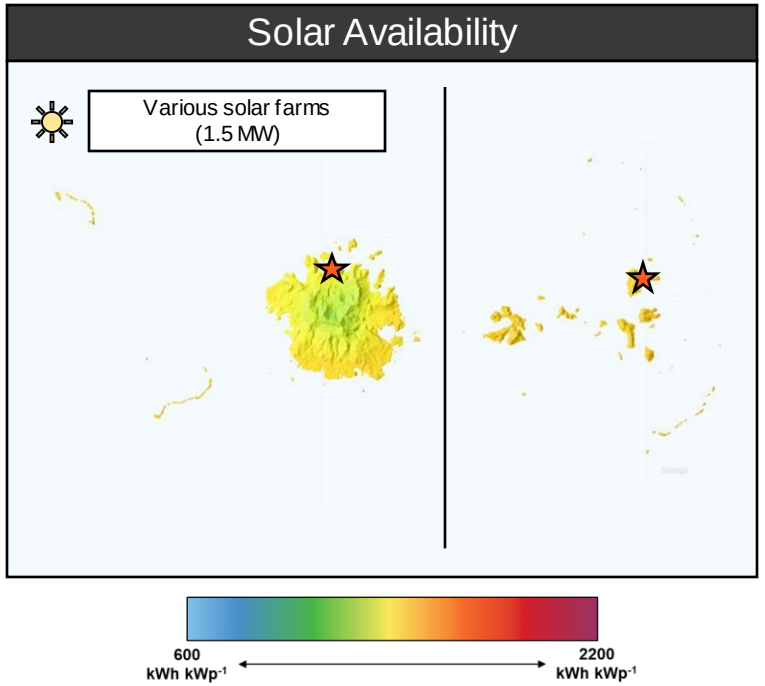
- Micronesia is targeting 100% electricity access by 2027, with renewables providing 63% of electricity (to increase to 84% by 2037).
- This leads to a target of a 65% reduction in CO_2 emissions from electricity below 2000 levels by 2030.
- Micronesia is targeting net zero emissions by 2050 through the Climate Ambition Alliance.



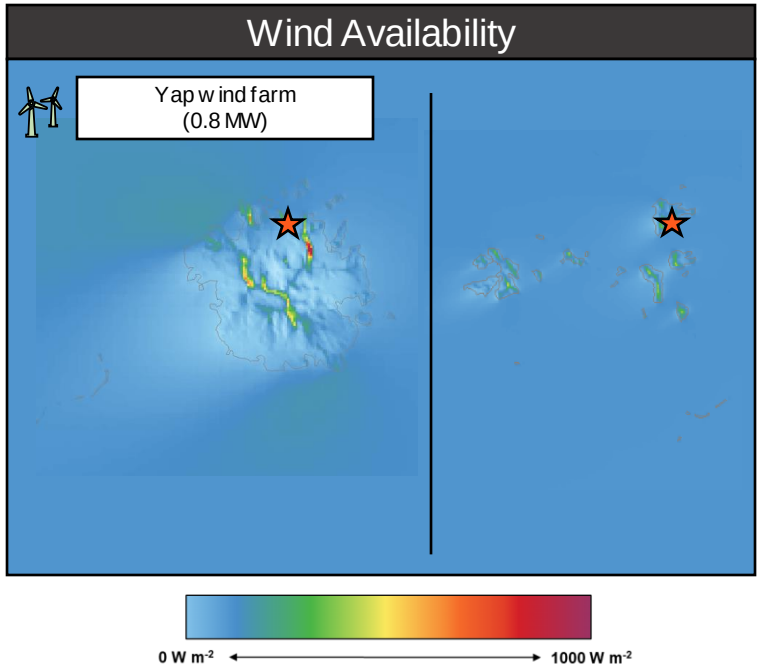
Legend

- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator

Solar Availability



Wind Availability



Population

- Micronesia consists of over 600 islands, of which 74 are inhabited.
- There are four semi-autonomous states, Yap (11% of the population), Chuuk (45%), Pohnpei (37%), and Kosrae (7%).
- Weno in Chuuk has the largest population of around 14,000.

Renewable Energy Potential

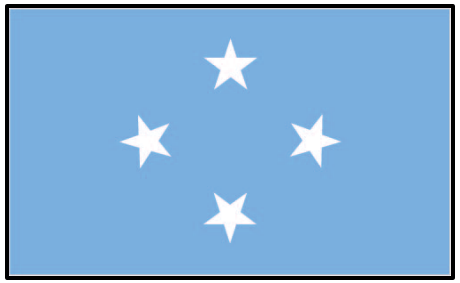
- Micronesia has good solar availability, as evidenced by the implementation of solar PV systems in each of the four states.
- There is also strong wind availability, with regions of Pohnpei experiencing very high wind energy density.

- The production of 16,000 tpa of hydrogen would require around:

0.81 TWh/yr of electricity

93 MW of electrolyser capacity

0.49 GL/yr of water



Micronesia's Power to X Potential

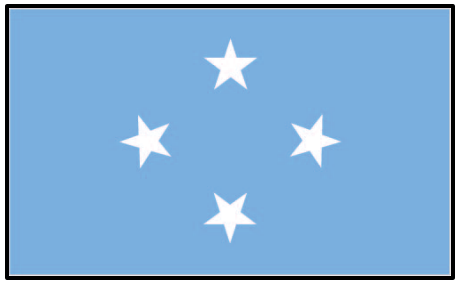
Micronesia is highly reliant on fossil fuels for 98% of its energy needs, particularly in the mobility sector and electricity generation. A shift to Power to X can enable energy security, especially in maritime and heavy transport. Micronesia has high solar availability, which is leading to the decarbonisation of electricity generation through solar PV projects.

Existing Targets and Strategies for Decarbonisation

- Micronesia's key energy and climate-related goals are outlined as such:
  - By 2030, increase access to electricity to 100% nationwide.
  - By 2030, increase electricity generation from renewable energy to more than 70% of total generation.
  - By 2030, reduce carbon dioxide emissions from electricity generation by more than 65% below 2000 levels.
  - By 2030, reduce black carbon and methane emissions related to diesel electric generation by more than 65% below 2000 levels.
- Micronesia notes that these goals are contingent upon access to means of implementation, requiring international assistance.
- Whilst domestic transport is a major contributor to Micronesia's total GHG emissions, the country currently does not have a strategy for decarbonising this sector. Current transport related goals include:
  - By 2030, climate-proof all major island ring roads, airport access roads, and arterial roads.
  - By 2030, complete climate-proofing of major ports.
- Improving energy efficiency is being targeted by:
  - Formulation of recommended energy conservation and energy efficiency policies, practices, and applications in public sector buildings.
  - Development of a public sector Building Energy Audit System (BEAS).
  - Design of energy conservation and efficiency technology application demonstrations.
  - Implementation of building energy conservation and energy efficiency demonstrations.

Figure 15. Chuuk Public Utility Corporation diesel generators in the main island of Weno.

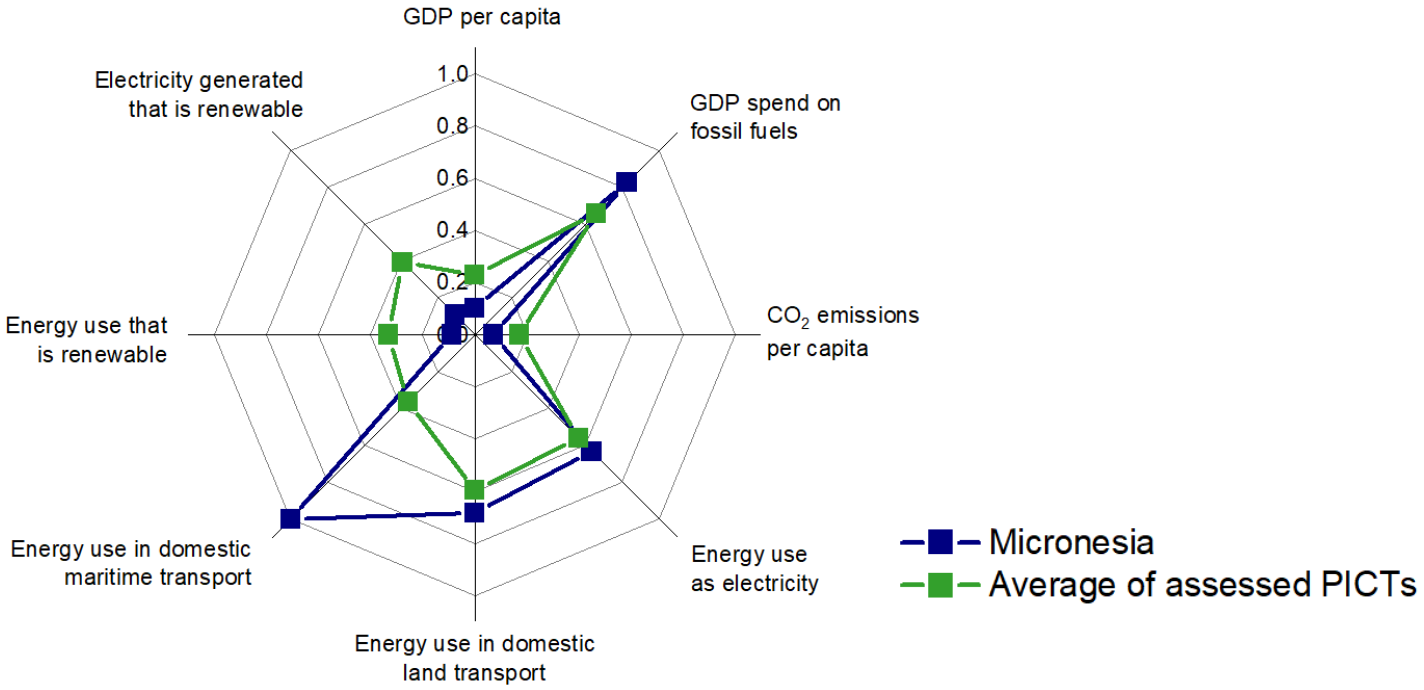
Figure 16. The 600 kW solar plant in Pohnpei.



Micronesia's Power to X Potential

Micronesia is highly reliant on fossil fuels for 98% of its energy needs, particularly in the mobility sector and electricity generation. A shift to Power to X can enable energy security, especially in maritime and heavy transport. Micronesia has high solar availability, which is leading to the decarbonisation of electricity generation through solar PV projects.

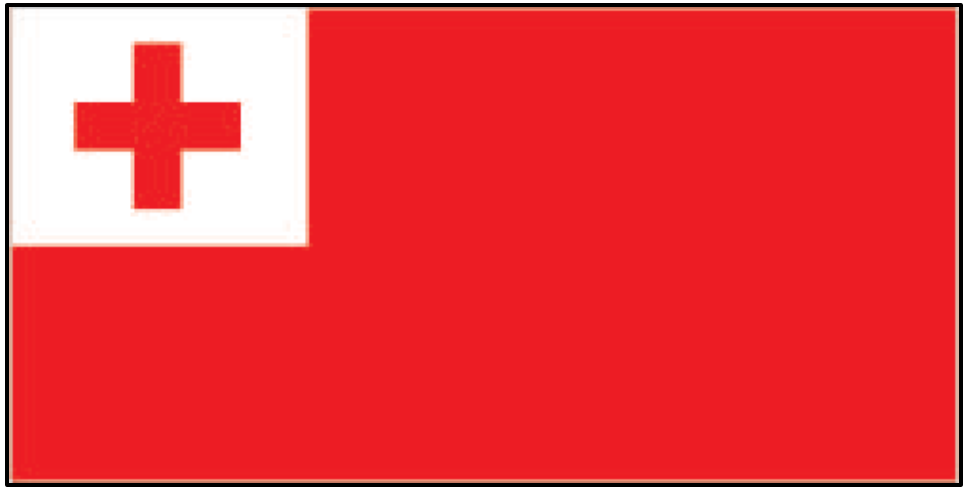
Competitive Advantage



- Micronesia spends a relatively high proportion of their GDP on fossil fuels. Due to the spread of the population amongst 74 islands and the four states, a significant use of energy is in domestic maritime transport.
- Micronesia has acceptable solar (8th highest in PICTs) and wind (5th highest in PICTs) energy potential with up to 83% energy accessibility/coverage.
- Micronesia can heavily decarbonise the domestic land and maritime transport sectors through Power to X, which are responsible for over 55% of CO_2 emissions.

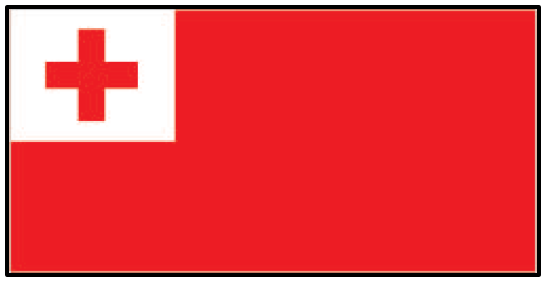
Critical Challenges

- Most of the Micronesian islands are low-lying atolls that are especially vulnerable to sea-level rise, which also increases coastal erosion and threatens agricultural productivity and water security due to intrusions of saltwater into croplands and freshwater reservoirs.
- Micronesia is currently highly dependent on fossil fuels for energy generation and is thus heavily exposed to volatile oil prices.
- Due to the wide spread of the islands of Micronesia, it is difficult to achieve 100% renewable electricity and net zero long terms targets. Although the scale of the individual projects needed to provide electricity is relatively small, several dozen projects are needed across numerous outer islands.
- The outer atolls also tend to be much less developed, creating challenges for building resilience, as they are not served by the nation's main water and energy systems, nor are they frequently served by national transportation systems.
- Key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies



H_2 Case Study:

Tonga



Overview

Population
- 107,000

Gross Domestic Product
- USD $0.51 B
- TOP $1.2 B

Land Area
- 747 km^2
- 43% agricultural land
- 13% forested land

Fossil Fuel Consumption
- 0.62 TWh
- 98% of annual energy use

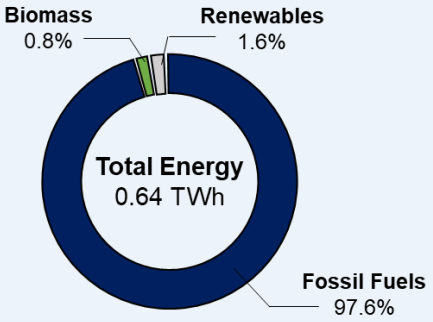
GDP Spent on Fossil Fuel Energy
- 7.0 %
- USD $36 M
- TOP $84 B

CO_2 Emissions
- 0.32 Mt of CO_2e per year
- 0.18 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

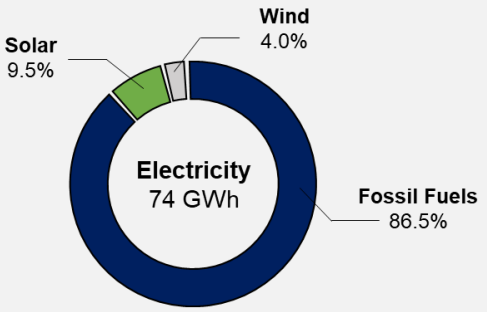
Energy Outlook

- Tonga's annual energy use is around 0.64 TWh, 98% of which is fossil fuel-based.
- Tonga imports 0.62 TWh of energy as various oils, primarily diesel (equivalent to 0.39 million bbl of diesel).
- Most energy is used in land transport (49%), as well as in electricity generation (27%).



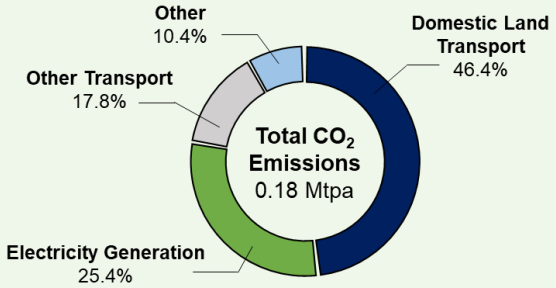
Electricity Mix

- Tonga produces over 85% of its electricity with fossil fuels. The installed capacity of diesel generators on Tongatapu is around 14 MW.
- Tonga has multiple solar farms spread across the islands. On Tongatapu, the total solar capacity is around 10 MW including the 6 MW Sunergise Tongatapu Solar Farm, the largest in the South Pacific.
- The Manumataongo Wind Farm (1.3 MW) is at the northeastern corner of Tongatapu.



CO_2 Emissions

- Tonga's total greenhouse gas emissions are 0.32 Mtpa of CO_2e.
- CO_2 emissions total 0.18 Mtpa, whilst the remainder of emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- Over 70% of CO_2 emissions can be attributed to domestic land transport and electricity generation.



Hydrogen Potential

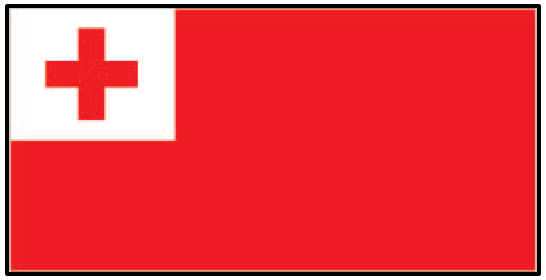
- A significant expense is associated with the fossil fuel use in key sectors, most notably domestic land transport, which costs USD $18 M per year.
- Around 17,000 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	104,000	9.57	980	2,400	4,900
Domestic Land Transport	190,000	17.5	1,800	4,500	8,900
Domestic Maritime Transport	72,600	6.68	680	1,700	3,400

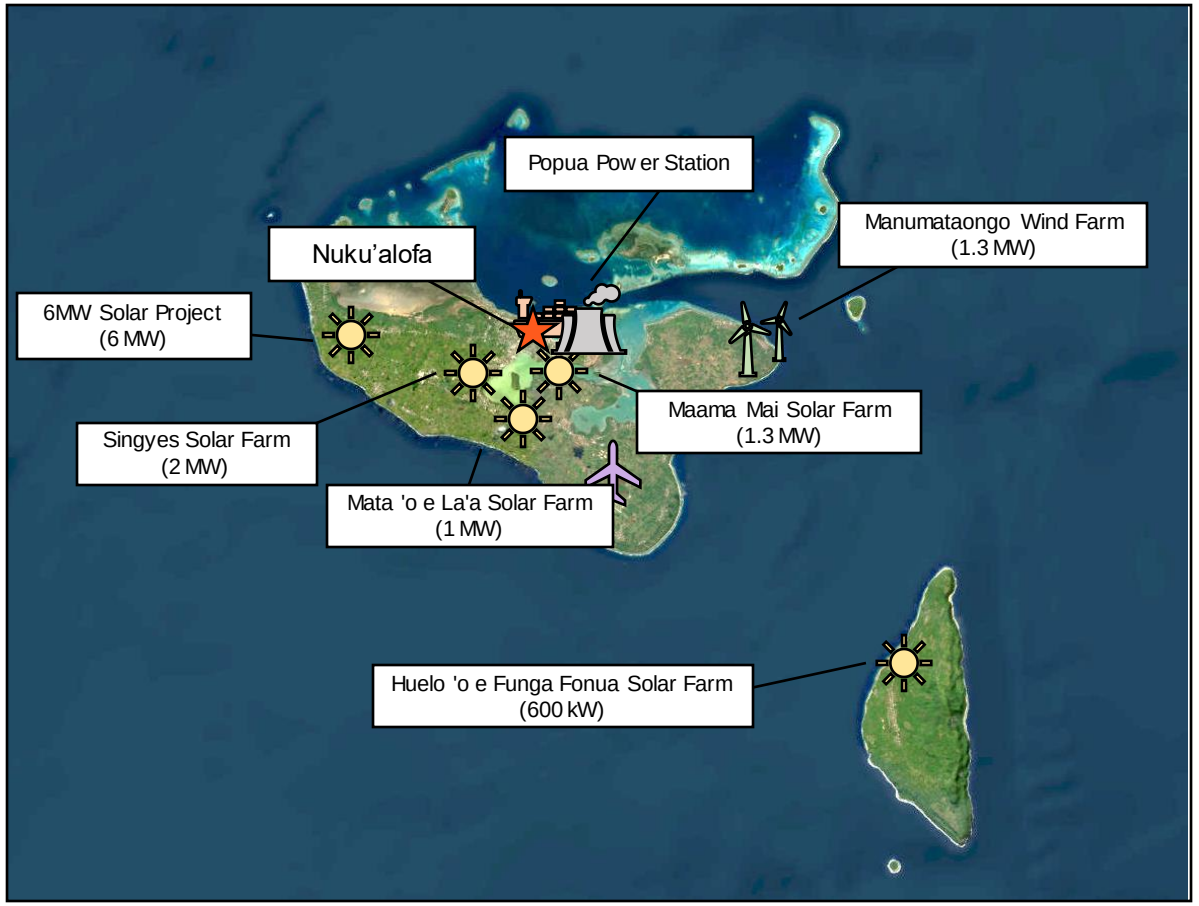
Targets

- Tonga's updated 2020 NDC outlines the following key mitigation targets:
  - 13% reduction in GHGs by 2030.
  - 70% renewable electricity by 2030.
  - Plant one million trees.
  - Expand the waste collection system.
- Tonga is targeting net zero emissions by 2050 through the Climate Ambition Alliance.

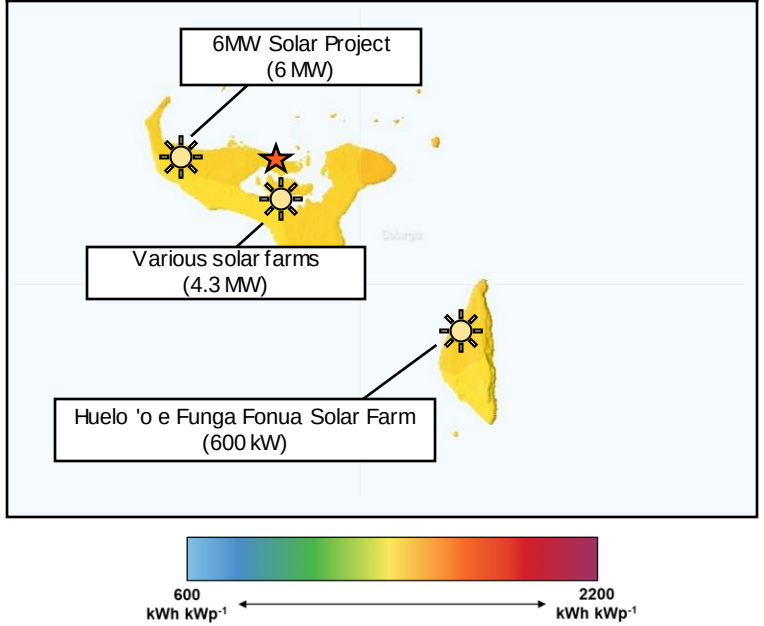


Legend

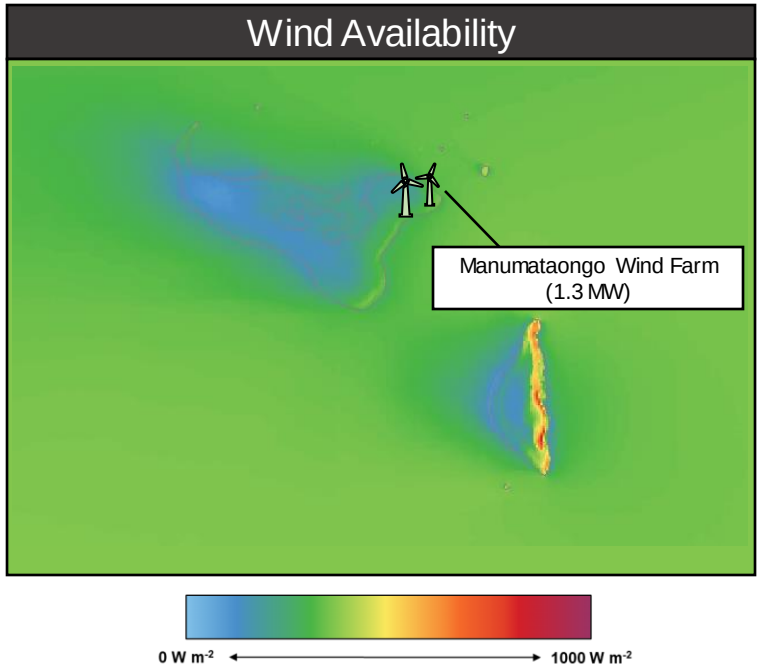
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



Population

- Most of the Tongan population lives in the three major island groups, and around 70% live on Tongatapu Island.
- The capital and largest city is Nuku'alofa, with a population of around 23,000.
- Around 77% of the population lives in rural areas, and 23% in urban areas.

Renewable Energy Potential

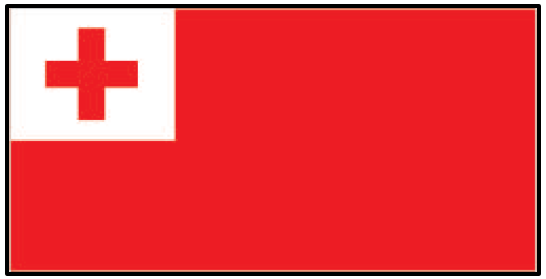
- Tonga has a high solar availability. There are numerous solar farms in operation, with more planned. The Tonga Renewable Energy Project (TREP) is focused on installing battery systems to store the solar energy.
- Tonga also has strong wind availability (the highest of the assessed PICTs).

- The production of 17,000 tpa of hydrogen would require around:

0.86 TWh/yr of electricity

98 MW of electrolyser capacity

0.52 GL/yr of water



Tonga's Power to X Potential

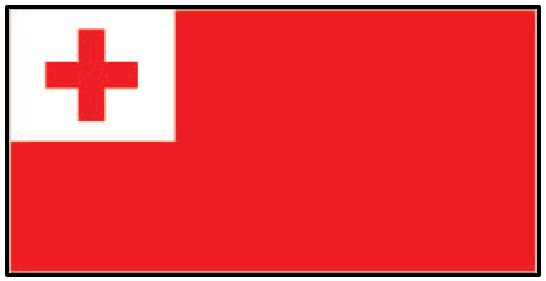
Tonga is highly reliant on fossil fuels for 98% of its energy needs, particularly in the mobility sector and electricity generation. A shift to Power to X can enable energy security, especially in heavy transport. Tonga has high solar and availability, which is leading to the decarbonisation of electricity generation through both solar and wind projects, as well as battery storage systems.

Existing Targets and Strategies for Decarbonisation

- Tonga's updated 2020 NDC includes four primary mitigation targets and means of achieving this goals.
- The first is a 13% reduction in GHG emissions compared to 2006 levels. This can be achieved by:
  - Generating 70% of electricity renewably, through the implementation of solar, wind, and battery storage.
  - Introduction of mandatory vehicle standards and/or incentives through tax, fees, and import tariffs.
  - Adoption of minimum energy performance standards.
- Other primary targets include:
  - Identification of a GHG emission target for agriculture, forestry and other land use.
  - Planting one million trees by 2023.
  - Identification of a GHG emission target for waste for the 2025 NDC.
- Tonga notes that these goals are contingent upon financing, upgrading of their network infrastructure, public acceptance, technical capacity, and consent from various stakeholders.

Figure 17. Battery energy storage system at the Popua power station.

Figure 18. The 6 MW solar farm in Tongatapu.



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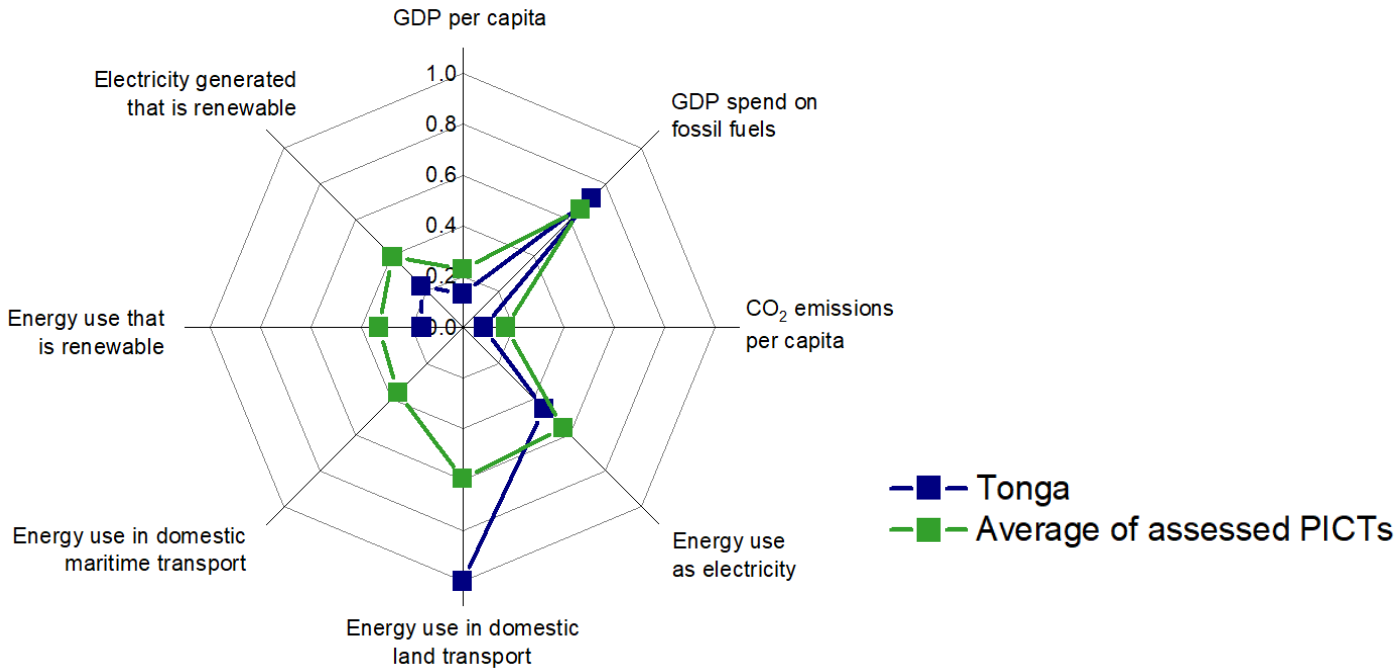
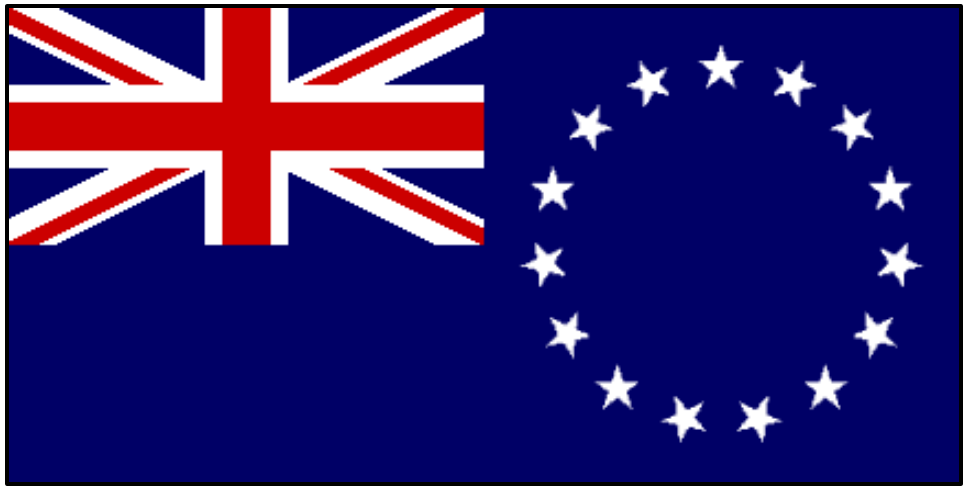
Competitive Advantage



- Tonga is highly reliant on imported fossil fuels for energy and is higher than the average of the assessed PICTs for GDP spend on fossil fuels.
- A significant proportion of this energy is used in land transport, presenting an opportunity to heavily decarbonise through the domestic land transport sector.
- Tonga has strong solar (5th highest in PICTs) and wind (highest of the PICTs) energy potential with up to 100% energy accessibility/coverage.

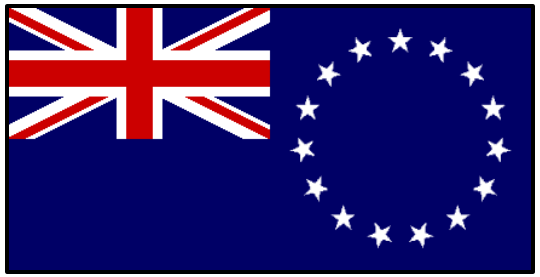
Critical Challenges

- Tonga is highly vulnerable to the impacts of climate change, ranked 3rd in the Climate Disaster Risk index.
- Agriculture is a crucial sector in Tonga, accounting for approximately 15% of the country's GDP in 2018/19, with a quarter of the country's employed laborers working in agriculture, forestry and fishing. This sector is strongly affected by the climate, including temperature, rainfall, and natural disasters.
- More than 80% of Tonga's population resides within a distance of less than 1 km from the shore, suggesting a very high vulnerability to rising sea levels.
- Key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.



H_2 Case Study:

Cook Islands



Overview

Population
- 17,000

Gross Domestic Product
- USD $0.33 B
- NZD $0.54 B

Land Area
- 236 km^2
- 8% agricultural land
- 65% forested land

Fossil Fuel Consumption
- 0.32 TWh
- 91% of annual energy use

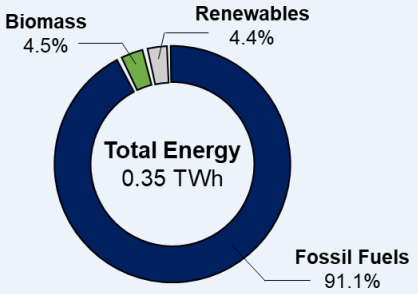
GDP Spent on Fossil Fuel Energy
- 5.6 %
- USD $18 M
- NZD $30 M

CO_2 Emissions
- 0.11 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

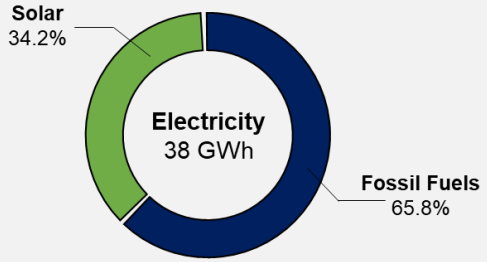
Energy Outlook

- Cook Islands annual energy use is around 0.35 TWh, 91% of which is fossil fuel-based.
- Cook Islands imports 0.32 TWh of energy as various oils, primarily diesel (equivalent to 0.20 million bbl of diesel).
- Most energy is used in transport (over 50%), as well as in electricity generation (28%).



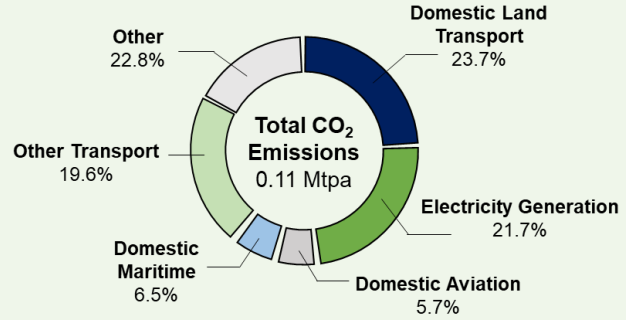
Electricity Mix

- Cook Islands produces over 65% of its electricity with fossil fuels.
- The remaining electricity is supplied by a range of solar farms spread across the islands, with a total solar capacity of around 6 MW.
- The Te Mana O Te Ra Solar Farm has a capacity of 960 kW, supplying 5% of Rarotonga's electricity needs.
- The Renewable Energy Sector Project plans to add around 6 MW of solar PV in total.



CO_2 Emissions

- Cook Island's estimated CO_2 emissions are 0.11 Mtpa
- Between 2007 to 2014, emissions were 83% CO_2, 10% CH_4, and 4% N_2O.
- Over 75% of CO_2 emissions can be attributed to transport and electricity generation.



Hydrogen Potential

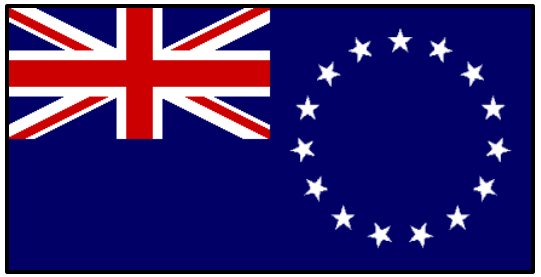
- A significant expense is associated with the fossil fuel use in key sectors, most notably domestic land transport, which costs USD $7.1 M per year.
- Around 8,500 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	55,800	5.13	520	1,300	2,600
Domestic Land Transport	77,600	7.14	730	1,800	3,600
Domestic Aviation Transport	31,300	2.88	290	730	1,500

Targets

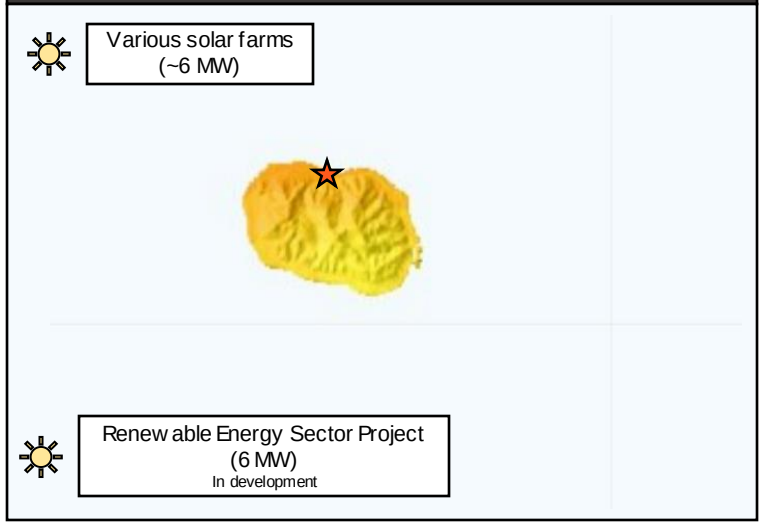
- Cook Islands' first NDC was submitted in 2015. The revised NDC is currently being prepared.
- 2020 targets included:
  - 100% of islands transformed from diesel-based to renewable energy sources.
  - Unconditionally reduce electricity generation emissions 38% below 2006 levels.
- Cook Islands is targeting net zero emissions by 2050 through the Climate Ambition Alliance.



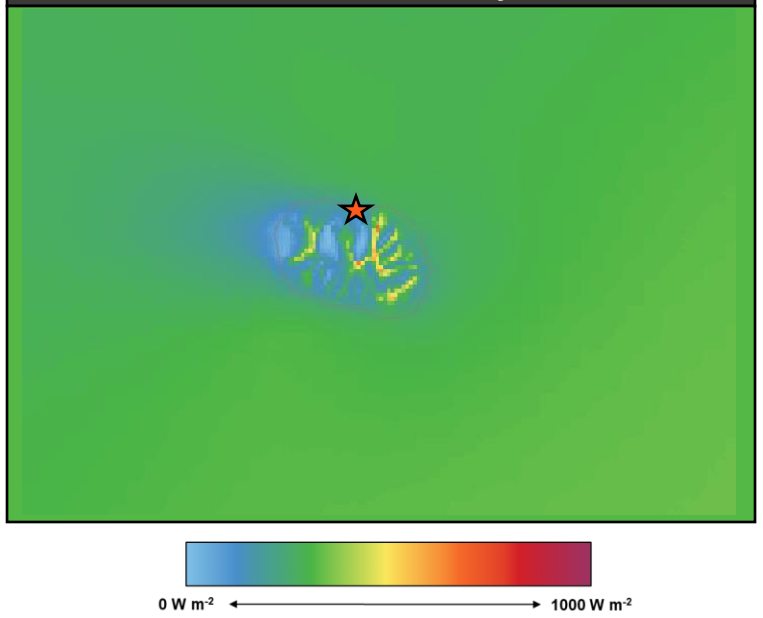
Legend

- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator

Solar Availability



Wind Availability



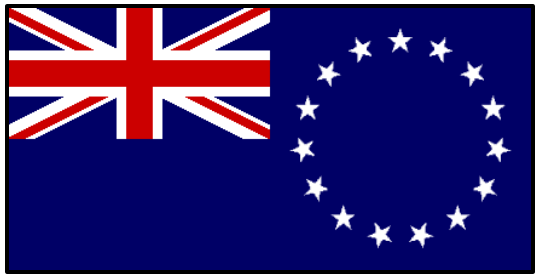
Population

- Cook Islands comprises 15 small islands, commonly divided into the northern group and the southern group.
- The largest island, Rarotonga, has a population of over 11,000 (around 70% of the total population).
- The population has been steadily declining due mainly to emigration, mostly to New Zealand and Australia.

Renewable Energy Potential

- The Cook Islands have strong solar and wind potential, ranking highly amongst the assessed PICTs.
- Decarbonisation of the Cook Island's electricity generation is being undertaken through the introduction of solar farms on each group of islands, and through the Renewable Energy Sector Project.

- The production of 8,500 tpa of hydrogen would require around:
  - 0.43 TWh/yr of electricity
  - 49 MW of electrolyser capacity
  - 0.26 GL/yr of water



Cook Island's Power to X Potential

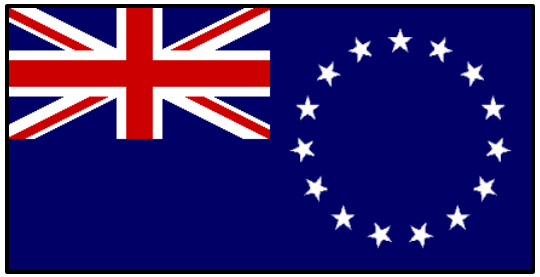
The Cook Islands are committed to generating their electricity renewably, decreasing reliance on fossil fuels and volatile oil prices. The solar generation potential in the Cook Islands is high, as evidenced by the introduction of solar farms on many islands. Power to X represents an opportunity to decarbonise the largest-emitting sector, land and maritime transportation.

Existing Targets and Strategies for Decarbonisation

- In the Cook Island's first 2015 NDC, the country committed to a future powered by renewable energy with targets of 50% of islands transformed from diesel based to renewably sourced electricity by 2015 to 100% coverage by 2020 . Furthermore, using 2006 as the base year, emission from electricity generation can be reduced by 38% by 2020.
- On receiving external support, Cook Islands could "reduce emissions from electricity generation by a further 43%, totaling an 81% emissions reduction by 2030 (relative to 2006).
- These reductions are being fulfilled by the implementation of solar farms across the islands, such as the Renewable Energy Sector Project, which includes international assistance.
- Electricity generation is the present focus, with transport powered by renewable energy to be the next decarbonisation focus. The Cook Islands is looking to embrace proven low carbon transport technologies and is currently exploring the most effective incentives for promotion of transition towards clean energy transportation.
- Future mitigation options in key sectors are outlined as such:
    - In the energy sector, solar electricity will become the primary source of electricity, although it is thought unlikely that the 100% RE option can be fulfilled unless large amounts of funding are secured, and substantial storage introduced to the required scale.
    - In energy efficiency, funding needs to be sought to provide energy audits for industry and commercial sectors and to provide training programs for energy auditing.
    - In the transport sector, a long-term plan needs to be put in place to change the present vehicle fleet to all electric vehicles, including public transport options. This transition would have to coordinate with the electricity sector plan to move to renewables.
    - In the waste sector, the conversion of the current household septic tank waste disposal system to a piped system with centralised disposal could provide opportunities for emissions reductions.

Figure 19. The Te Mana O Te Ra solar farm at Rarotonga airport.

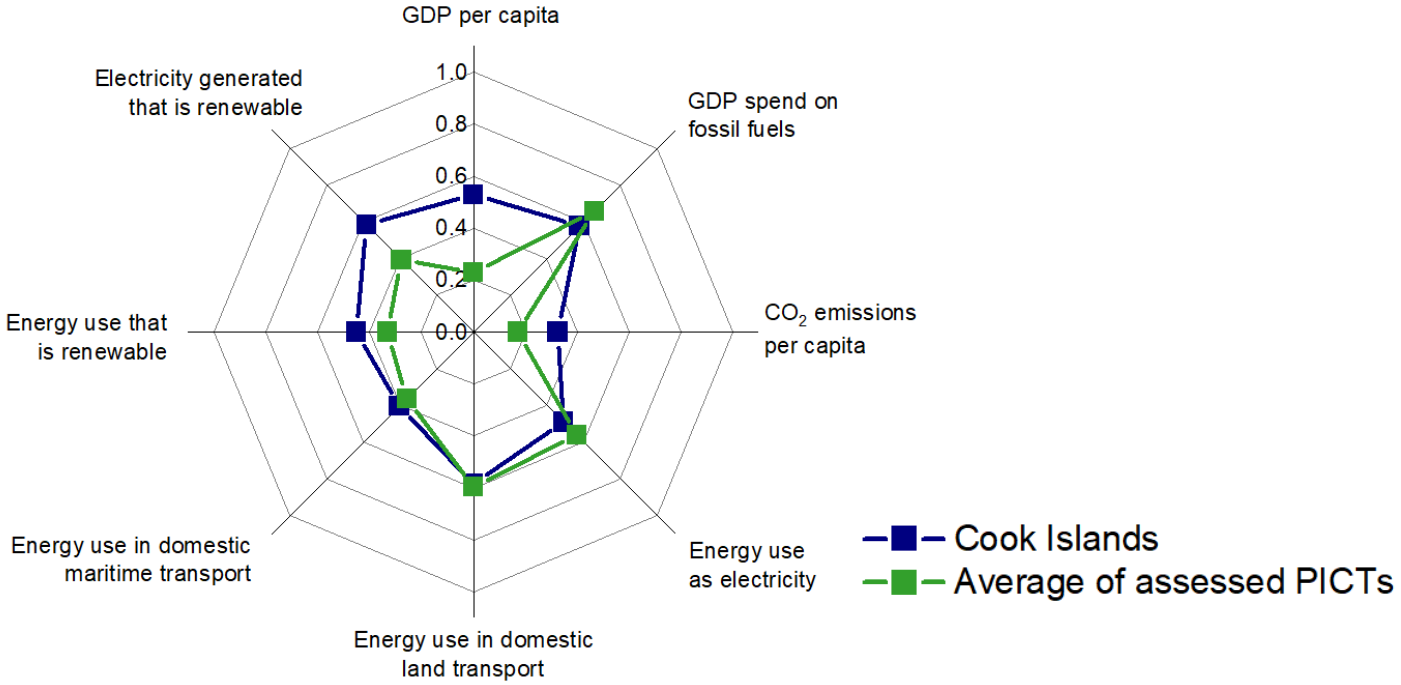
Figure 20. A cruise boat in the Cook Islands.



Cook Island's Power to X Potential

Cook Islands are committed to generating their electricity renewably, decreasing reliance on fossil fuels and volatile oil prices. The solar generation potential in the Cook Islands is high, as evidenced by the introduction of solar farms on many islands. Power to X represents an opportunity to decarbonise the largest-emitting sector, land and maritime transportation.

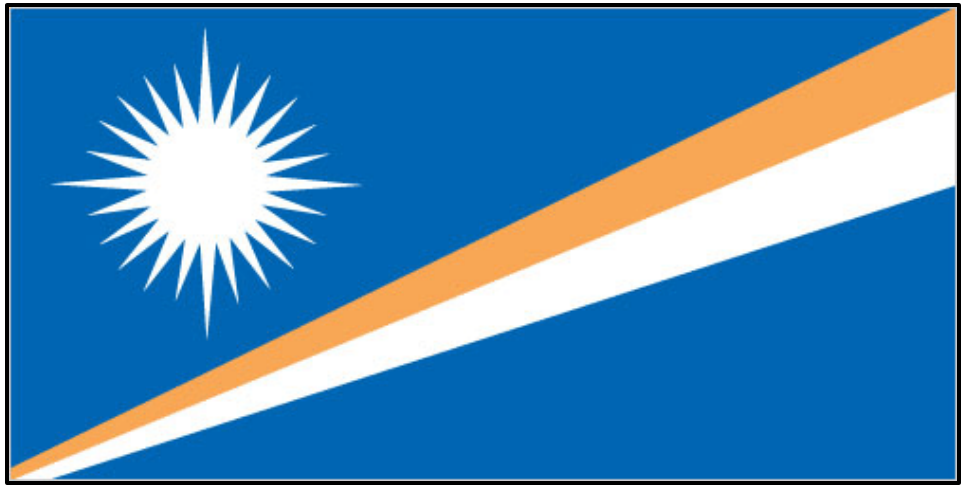
Competitive Advantage



- Cook Islands emits a high volume of CO_2 per capita, due to the low population and spread across the islands. Electricity generation is over 30% renewable and will trend towards 100% with the introduction of further solar farms.
- Cook Islands has strong solar (3rd highest in PICTs) and good wind (8th highest in PICTs) energy potential with up to 99% energy accessibility/coverage.
- Transport (consisting primarily of buses, cars, motorbikes, motorised boats, and small 18-seater planes) accounts for over 50% of CO_2 emissions, presenting an opportunity to heavily decarbonise through Power to X.

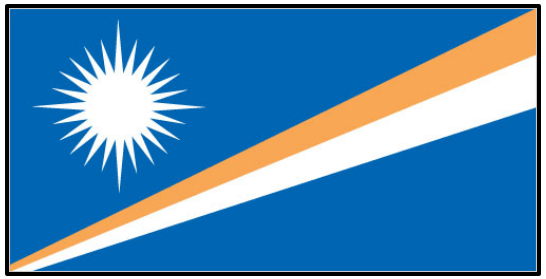
Critical Challenges

- More intense tropical cyclones with an increase in the average maximum wind speeds and rainfall intensity. Rising sea surface temperatures are expected to coincide with an increase in coral bleaching, rising sea levels, and an increase in the intensity, duration and frequency of extreme weather events.
- The country's response to climate change must consider the disparity between Rarotonga and other islands, which have much less developed infrastructure, small populations that are declining and a workforce dominated by public sector jobs. These islands experience a higher cost of living due to extra freight costs for all commercial products.
- Challenges for decarbonisation outlined by the Cook Islands include:
  - Limited access to capital.
  - Trade barriers.
  - Vested interests by larger extraction and construction companies.
  - Regional cooperation.
  - Access to information.
  - Economic incentives.
- Other key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - Human capacity.
  - Enabling policies.



H_2 Case Study:

Republic of the Marshall Islands



Overview

Population
- 42,000

Gross Domestic Product
- USD $0.28 B

Land Area
- 181 km^2
- 51% agricultural land
- 1% forested land

Fossil Fuel Consumption
- 0.35 TWh
- 99% of annual energy use

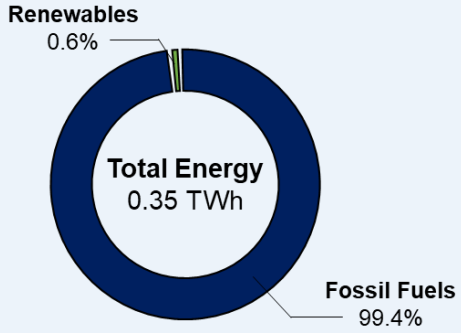
GDP Spent on Fossil Fuel Energy
- 7.1 %
- USD $20 M

CO_2 Emissions
- 0.16 Mt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

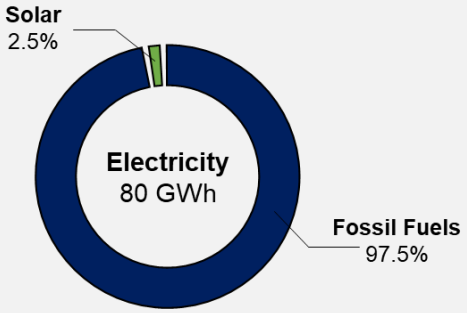
Energy Outlook

- The Republic of the Marshall Islands (Marshall Islands) annual energy use is around 0.35 TWh, 99% of which is fossil fuel-based.
- Marshall Islands imports 0.35 TWh of energy as various oils, primarily diesel (equivalent to 0.22 million bbl of diesel).
- Most energy is used in electricity generation (over 60%) and in domestic land transport (over 35%).



Electricity Mix

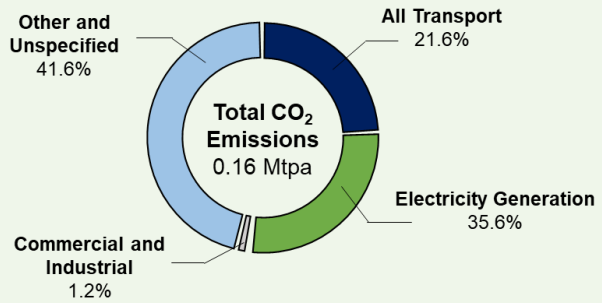
- Marshall Islands produces over 97% of its electricity with fossil fuels.
- The remaining electricity is supplied by solar PV projects on Majuro, totalling around 1 MW.
- More than 90% of the country's outer islands now use solar energy.
- Majuro's grid currently produces 74% of electricity sector GHG emissions, and Ebeye 22%.



CO_2 Emissions

- Marshall Island's estimated CO_2 emissions are 0.16 Mtpa, whilst other GHG emissions are mainly generated by waste and agriculture
- Around 50% of CO_2 emissions are related to transport and electricity generation, and it is likely that unspecified emissions also fall into these main sectors.

Note: Other and unspecified may include emissions relating to transport, electricity generation, and commercial and industrial use.



Hydrogen Potential

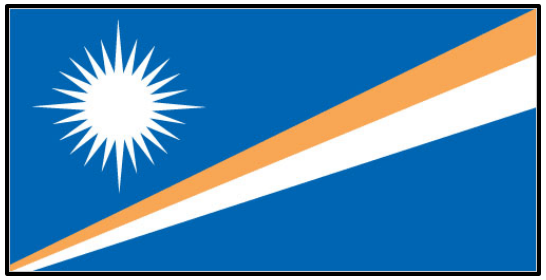
- A significant expense is associated with the fossil fuel use in key sectors, most notably for electricity generation, which costs USD $12.1 M per year.
- Around 9,900 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	132,000	12.1	1,200	3,100	6,200
All Transport	80,200	7.38	750	1,900	3,800

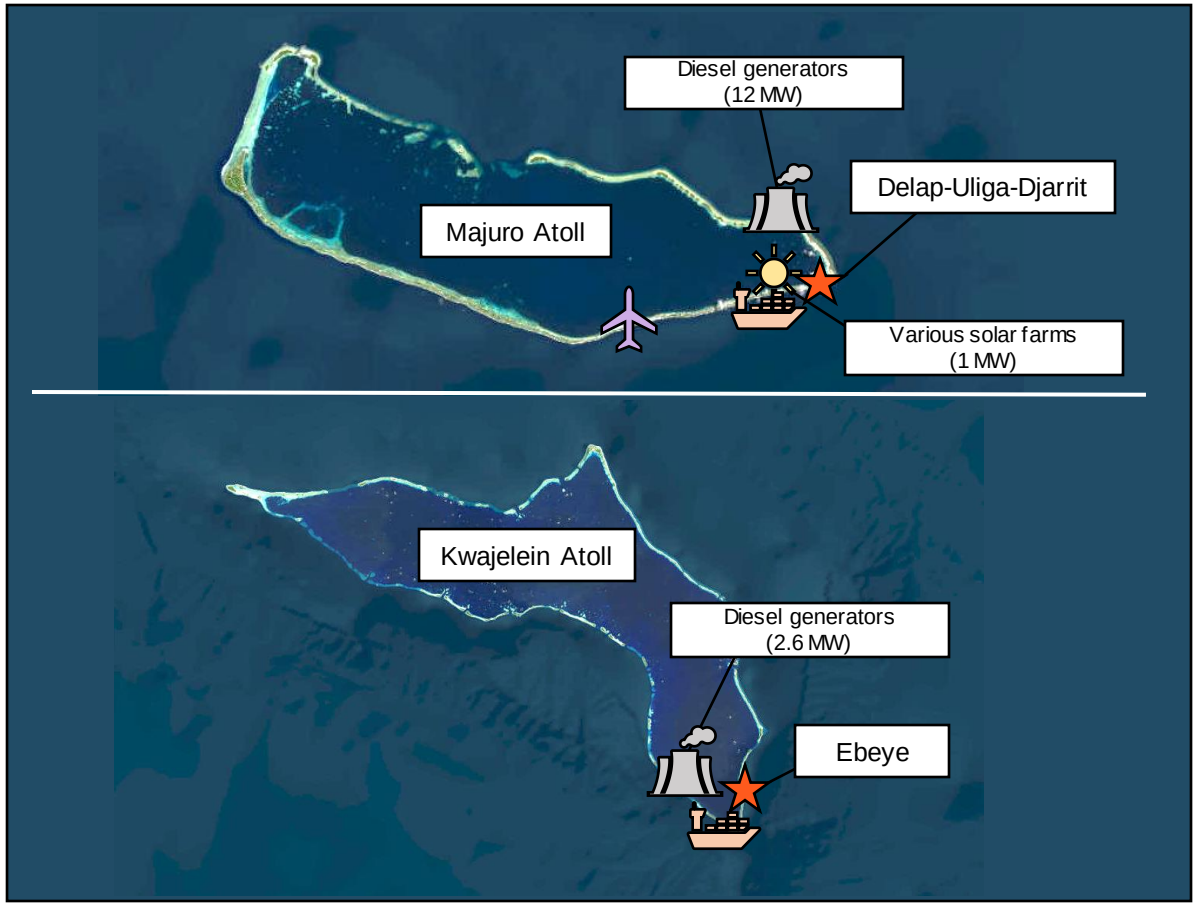
Targets

- Marshall Islands' 2018 updated NDC outlines key targets of reducing GHG emissions by:
  - 32% by 2025
  - 45% by 2030
  - 58% by 2035
- Marshall Islands aims to achieve net zero greenhouse gas emissions by 2050 at the latest.

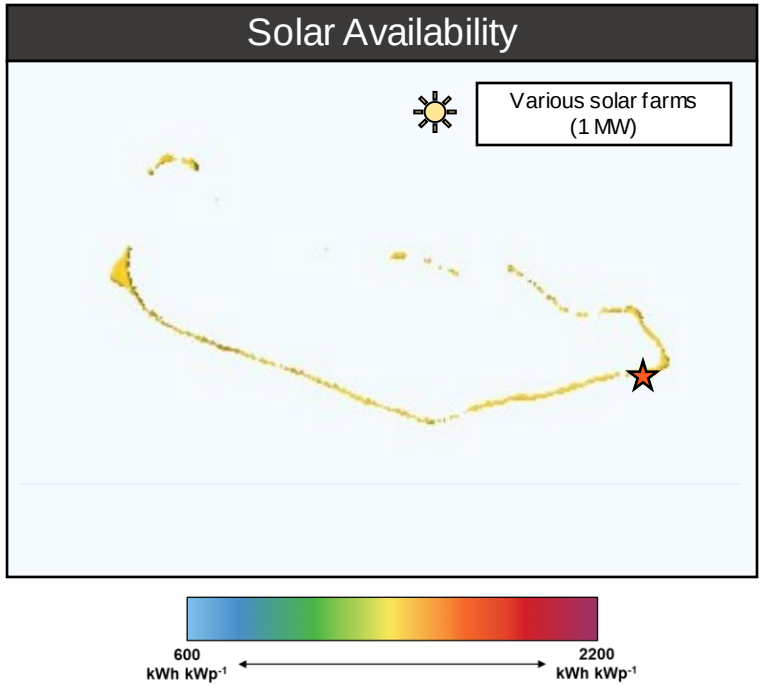


Legend

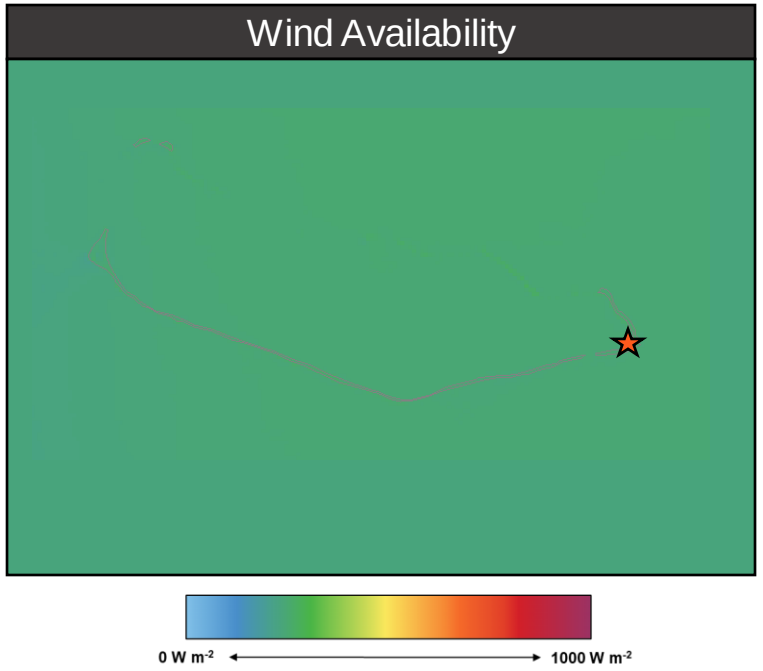
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



Population

- The Marshall islands consists of around 1,156 individual islands/islets, and 29 different atolls.
- Around 25,000 (over 50%) of the population lives on Majuro.
- Around 15,000 (around 35%) of the population lives on Ebeye.

Renewable Energy Potential

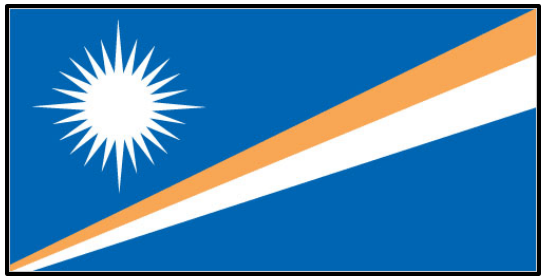
- There is currently little data on the solar and wind availability in the Marshall Islands.
- Wind energy has potential for Majuro and Ebeye, on the reef flats or offshore.
- Solar energy has potential (as evidenced by the current solar PV plants), however the Marshall Islands has very limited land availability.

- The production of 9,900 tpa of hydrogen would require around:

0.50 TWh/yr of electricity

57 MW of electrolyser capacity

0.30 GL/yr of water



Marshall Island's Power to X Potential

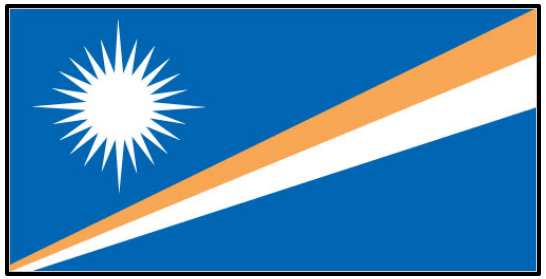
The Marshall Islands is heavily dependent on fossil fuels, making up 99% of its total energy usage. Land area is scarce, limiting the application of solar PV or wind for renewable energy generation. Power to X represents an opportunity to assist in the decarbonisation of the largest-emitting sectors; electricity generation and transportation.

Existing Targets and Strategies for Decarbonisation

- In the Marshall Islands' 2018 NDC, the country committed to:
  - Reduce its emissions of GHGs to at least 32% below 2010 levels by 2025 and to at least 45% below 2010 levels by 2030.
  - An indicative target to reduce its emissions of GHGs by at least 58% below 2010 levels by 2035.
  - An aspiration to achieve net zero GHG emissions by 2050 at the latest.
- The sectors targeted include energy (electricity generation, transport, cooking and lighting), as well as waste.
- Strategies to achieve these goals include:
  - Implementation of solar PV systems. More than 90% of the country's outer islands have been completely solarised, whilst major projects are planned for the larger atolls. Assistance is also being provided by the Asian Development Bank and the World Bank, in improving energy security and installing solar and hybrid systems.
  - Installation of energy storage capacity.
  - Devote 50% of copra (coconut oil) for use as a renewable fuel.
  - Introduction of electric vehicles.
  - Efficiency improvements and standards for other appliances.
  - Options are being assessed for reducing emissions from waste, including waste-to-energy, incineration, and landfilling.

Figure 21. 600 kW solar PV system on Majuro.

Figure 22. The shipping port on Majuro.



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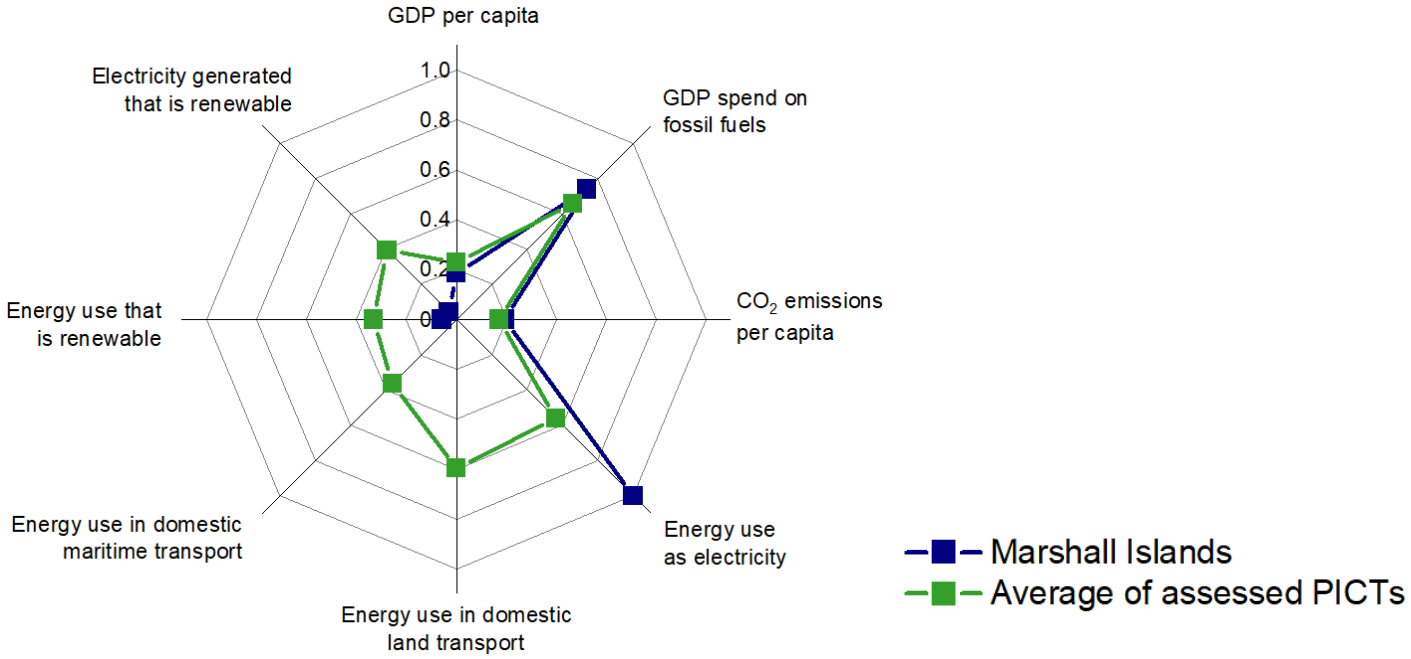
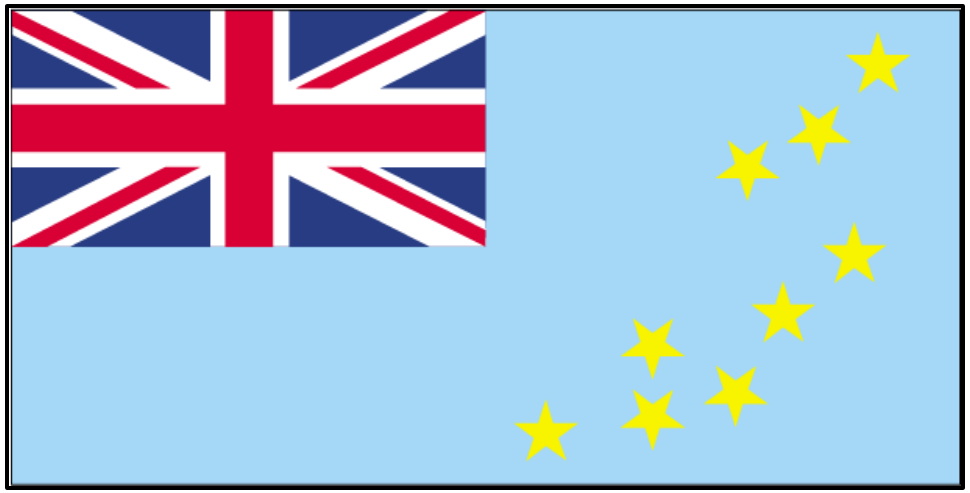
Competitive Advantage



- The Marshall Islands spends a large proportion of its GDP on fossil fuels, translating to a high CO_2 emissions per capita and leaving the country heavily exposed to volatile oil prices.
- The current data on solar and wind availability in the Marshall Islands is lacking. There is potential for the implementation of solar and wind energy, however land space is limited. Solar energy accounts for less than 1% of total energy usage.
- Transport and electricity generation accounts for the vast majority of CO_2 emissions, presenting an opportunity to heavily decarbonise through Power to X.

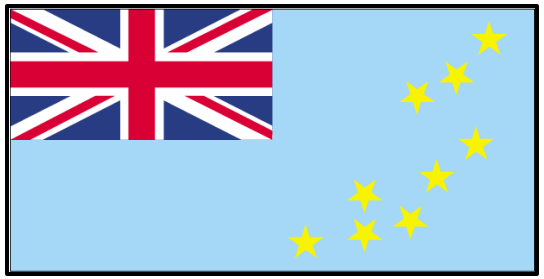
Critical Challenges

- The Marshall Islands is one of world's most climate vulnerable nations, and is seeing more frequent and intense events, such as drought, floods and swells, and tropical cyclones and storms. RMI declared a State of Disaster in 2013 and 2016 as a result of prolonged and unseasonal droughts. In 2015, Typhoon Nangka cost RMI more than 3% of its GDP in a single night. The average elevation is only two meters above sea level.
- The energy infrastructure is aging, with all generators near or beyond their useful life.
- Land is scarce, and non-government rooftops are not structurally capable of supporting PV arrays. There is about 7 MW worth of existing usable space on land and roofs in Majuro, however Majuro would need 40 MW of solar capacity to decarbonise its electricity grid.
- Around 30% of the population in Majuro and Ebeye live below the basic needs poverty line, with double that percentage living in poverty in the outer rural areas.
- Key challenges for decarbonisation include:
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.



H_2 Case Study:

Tuvalu



Overview

Population
- 11,000

Gross Domestic Product
- USD $60 M
- TVD $91 M

Land Area
- 26 km^2
- 60% agricultural land
- 33% forested land

Fossil Fuel Consumption
- 38 GWh
- 95% of annual energy use

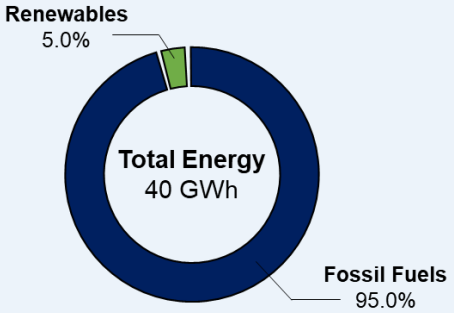
GDP Spent on Fossil Fuel Energy
- 3.6 %
- USD $2.2 M
- TVD $3.3 M

CO_2 Emissions
- 21.7 kt of CO_2e per year
- 10 kt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

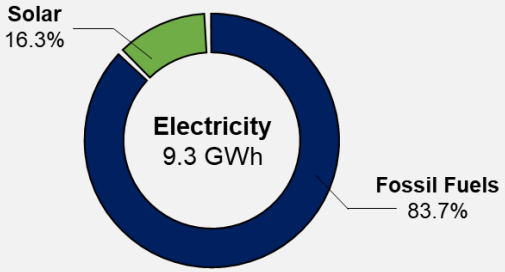
Energy Outlook

- Tuvalu's annual energy use is around 40 GWh, 95% of which is fossil fuel-based.
- Tuvalu imports 38 GWh of energy as various oils, primarily diesel (equivalent to 24,000 bbl of diesel).
- Most energy is used in electricity generation (over 50%) and domestic land transport (around 25%).



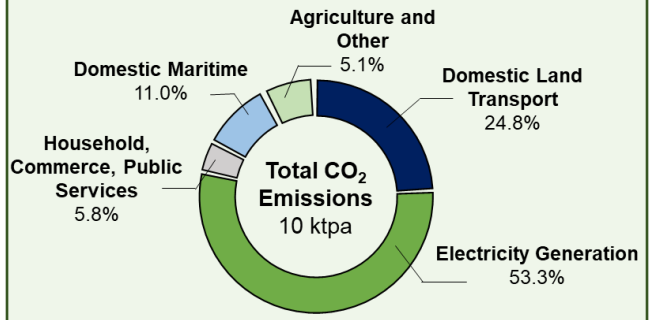
Electricity Mix

- Tuvalu is powered primarily by diesel generators, supplying over 80% of total electricity.
- The outer islands are powered by hybrid solar PV systems with diesel generators on standby.
- Funafuti consists of a few solar PV systems, however, is mostly powered by diesel generators.



CO_2 Emissions

- Tuvalu's total greenhouse gas emissions are 21.7 ktpa of CO_2e.
- CO_2 emissions total 10 ktpa, whilst the remainder of emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- As of 2019, there were 40 biogas digesters in Tuvalu.
- Over 85% of CO_2 emissions can be attributed to domestic transport and electricity generation.



Hydrogen Potential

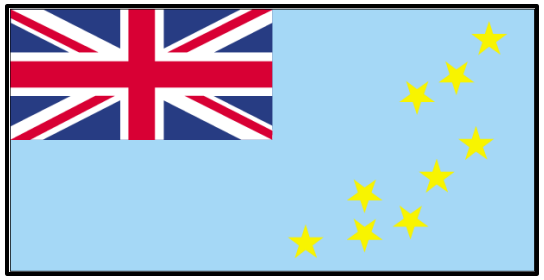
- A significant expense is associated with the fossil fuel use in key sectors, most notably electricity generation, which costs USD $1.2 M per year.
- Around 1,100 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	12,600	1.16	120	300	590
Domestic Land Transport	8,050	0.74	75	190	380
Domestic Maritime Transport	3,550	0.33	33	83	170

Targets

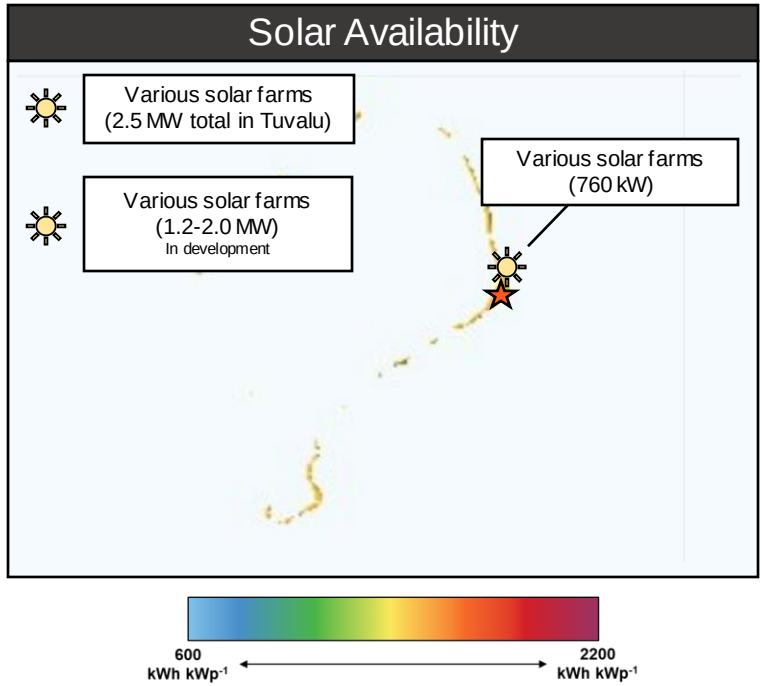
- Tuvalu's updated 2022 NDC outlines the following key mitigation targets:
  - Reduction of GHGs from the power sector by 100% by 2030.
  - Increase energy efficiency on Funafuti by 30%.
  - Energy sector GHG reduction of 60% by 2030.
- Tuvalu is targeting net zero emissions by 2050 through the Climate Ambition Alliance, and plans to develop a zero-carbon pathway for 2050.



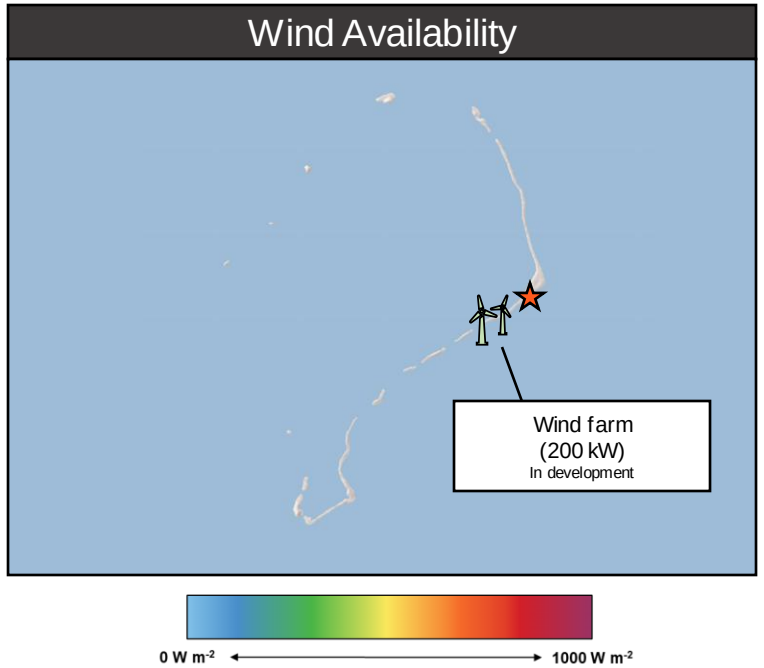
Legend

- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator

Solar Availability



Wind Availability



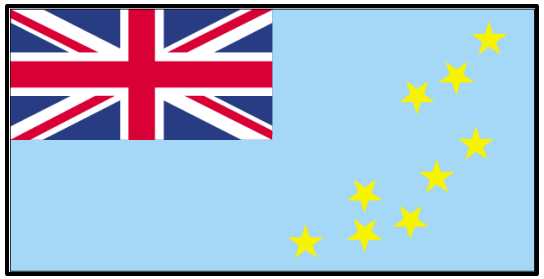
Population

- Tuvalu consists of nine small islands (six atoll islands and three raised limestone reef islands).
- Funafuti is the capital and largest city, with a population of over 6,000 (over 50%) of the total population.

Renewable Energy Potential

- Tuvalu has strong solar potential, as evidenced by the penetration of solar in the electricity mix, as well as plans for installation of further solar PV systems.
- The wind potential is fairly low, however there are plans to develop a 200 kW wind turbine on Funafuti, to further assess wind energy potential.

- The production of 1,100 tpa of hydrogen would require around:
  - 57 GWh/yr of electricity
  - 6.5 MW of electrolyser capacity
  - 34 ML/yr of water



Tuvalu's Power to X Potential

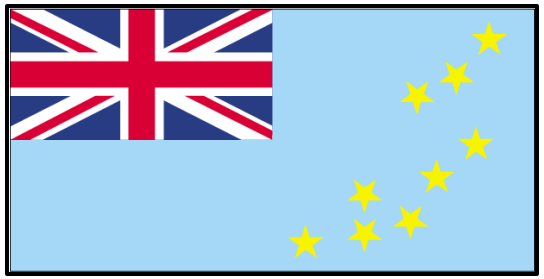
Tuvalu is heavily dependent on fossil fuels, making up 95% of its total energy usage. Tuvalu has strong solar potential, with a range of solar PV projects that could decarbonise 90% of electricity generation. Power to X represents an opportunity to assist in the decarbonisation of land and maritime transport.

Existing Targets and Strategies for Decarbonisation

- Tuvalu's updated 2022 NDC outlines key targets for reducing GHG emissions from the energy sector. These include:
  - Reducing emissions of GHGs from electricity generation by 100% by 2030.
  - Reducing GHG emissions from the energy sector by 60% by 2030 (compared to 2010 levels).
- Targets to decarbonise electricity production are to increase:
  - Solar PV to 60-95% of total demand.
  - Wind energy to 0-40% of total demand.
  - Biodiesel to 5% of total demand
- Renewable energy projects include:
  - The Tuvalu Energy Sector Development Project sponsored by the World Bank, which involves the installation of 700 kW of solar PV and 1 MW of battery storage.
  - The Increasing Access to Renewable Energy Project sponsored by the Asian Development Project, which involves the installation of 500 kW of solar PV and 1 MW of battery storage.
- Following the completion of these projects, Funafuti is expected to achieve a renewable energy contribution of approximately 90%. This will mean that nationwide, Tuvalu will generate approximately 90% of its electricity through renewable sources.
- Other actions that may be undertaken include:
  - Introduction of solar-powered bikes.
  - Exploration of domestic maritime decarbonisation options.
  - Identify GHG emissions reduction pathways in the AFOLU sector.
  - Identify GHG emissions reduction pathways in the waste sector.

Figure 23. The first grid-connected solar PV system in Tuvalu (40 kW).

Figure 24. Flooding at the Funafuti power station in 2007.



Tuvalu's Power to X Potential

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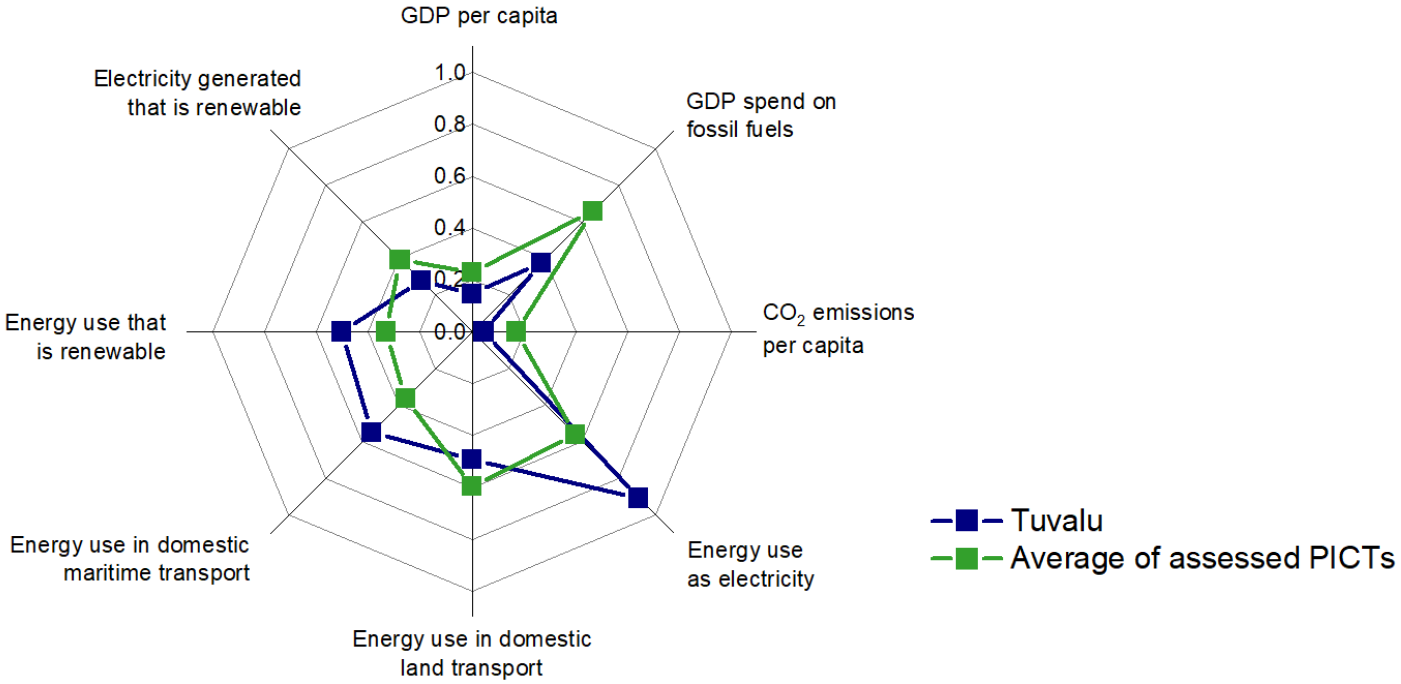
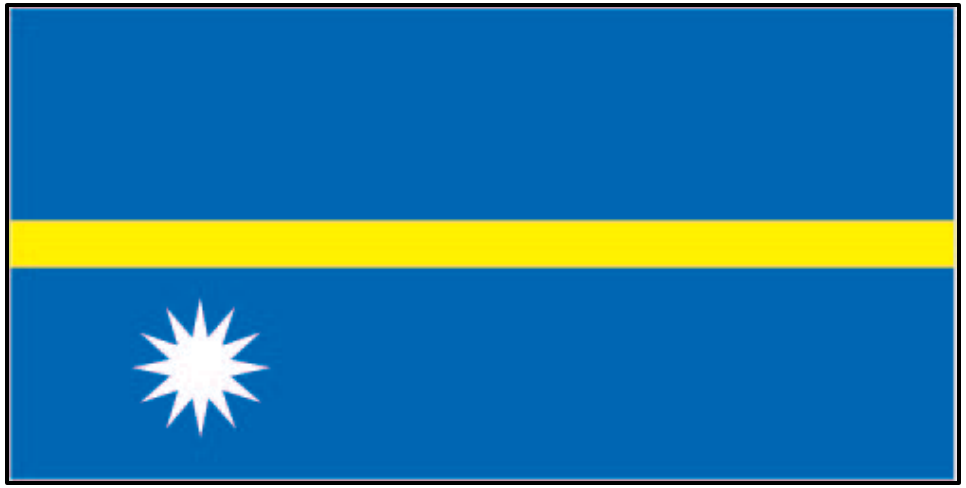
Competitive Advantage



- Tuvalu spends a relatively small proportion of its GDP on fossil fuels, however 95% of energy is supplied by imported fossil fuels, leaving the country heavily exposed to volatile oil prices.
- Tuvalu has strong solar (5th highest in PICTs) but low wind (9th highest in PICTs) energy potential with up to 100% energy accessibility/coverage.
- Transport (land and maritime) and electricity generation accounts for the vast majority of CO_2 emissions, presenting an opportunity to heavily decarbonise through Power to X.

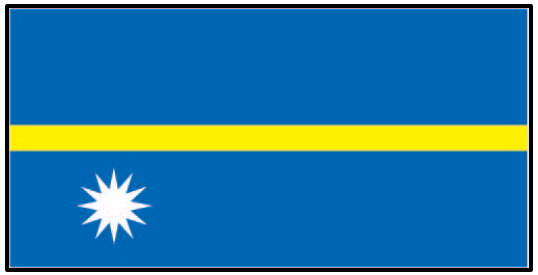
Critical Challenges

- Tuvalu is the world's second lowest-lying country and sea level rise poses a significant risk, with a highest elevation only 5 m above sea level.
- Storm surges, king tides, and floods are common occurrences and have intensified due to changes in weather patterns and sea-level rise.
- Tuvalu has a narrow economic base with the fisheries sector contributing up to 60% of the Government's revenue. Other significant revenue sources include sovereign wealth contracts and donor aid.
- Whilst Tuvalu is on track to decarbonise electricity generation, decarbonisation of transport in Tuvalu may prove challenging, particularly domestic maritime transportation.
- Key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.



H_2 Case Study:

Nauru



Overview

Population
- 13,000

Gross Domestic Product
- USD $0.15 B
- AUD $0.23 B

Land Area
- 21 km^2
- 20% agricultural land
- 0% forested land

Fossil Fuel Consumption
- 37 GWh
- 93% of annual energy use

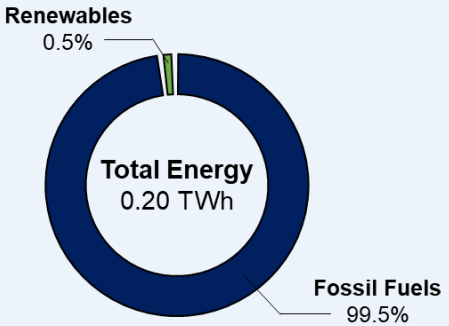
GDP Spent on Fossil Fuel Energy
- 7.8 %
- USD $12 M
- AUD $18 M

CO_2 Emissions
- 65 kt of CO_2e per year
- 60 kt of CO_2 per year

*Based solely on an estimate of ~US $ 92 per bbl equivalent of fossil fuels in energy use.

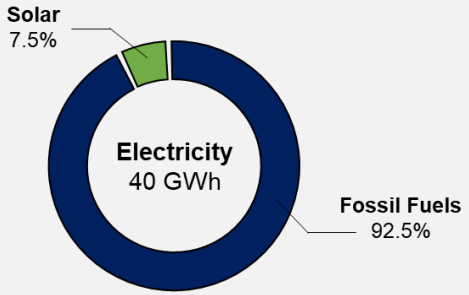
Energy Outlook

- The Republic of Nauru's (Nauru) annual energy use is around 0.20 TWh, over 99% of which is fossil fuel-based.
- Nauru imports almost all of its energy as various oils, primarily diesel (equivalent to 0.13 million bbl of diesel).
- Most energy is used in electricity generation (around 47%) and transport (around 30%).



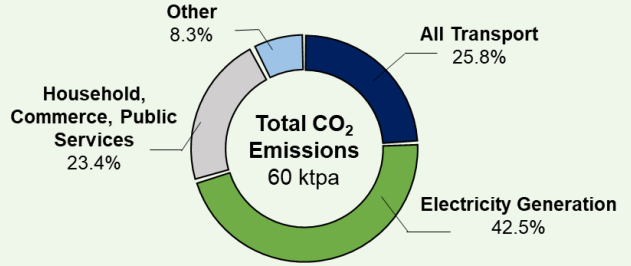
Electricity Mix

- Nauru generates over 92% of electricity through fossil fuels.
- The remaining electricity is generated from a 500kW solar farm and a number of small-scale rooftop solar panels.
- Several projects are planned to significantly increase the share of electricity generated by solar PV.



CO_2 Emissions

- Nauru's total greenhouse gas emissions are 65 ktpa of CO_2e.
- CO_2 emissions total 60 ktpa, whilst the remainder of emissions are CH_4 and N_2O, which occur mostly from the agricultural sector and from waste.
- Almost 70% of CO_2 emissions can be attributed to transport and electricity generation.
- Around 25% of emissions occur from households, commerce, and public services.



Hydrogen Potential

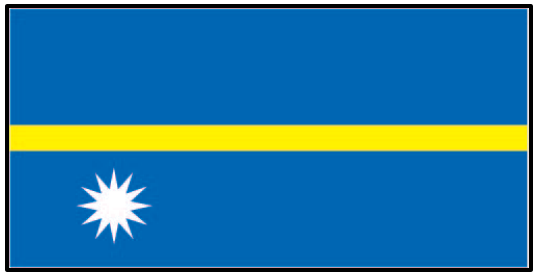
- A significant expense is associated with the fossil fuel use in key sectors, most notably electricity generation, which costs USD $5.4 M per year.
- Around 4,500 tpa of hydrogen would be required to fully displace fossil fuel use in these sectors.

Note: 1 tonne of green H_2 (120 MJ/kg) is required to generate 5.7 tonnes of green ammonia (18.8 MJ/kg), 5.0 tonnes of green methanol (20.1 MJ/kg), or 2.0 tonnes of sustainable aviation fuel (43 MJ/kg).

Sector	Equivalent Diesel Use (bbl)	Fossil Fuel Cost (USD $M)	Hydrogen Required to Displace (tpa)		
			20%	50%	100%
Electricity Generation	59,300	5.42	560	1,400	2,800
All Transport	35,900	3.31	340	840	1,700

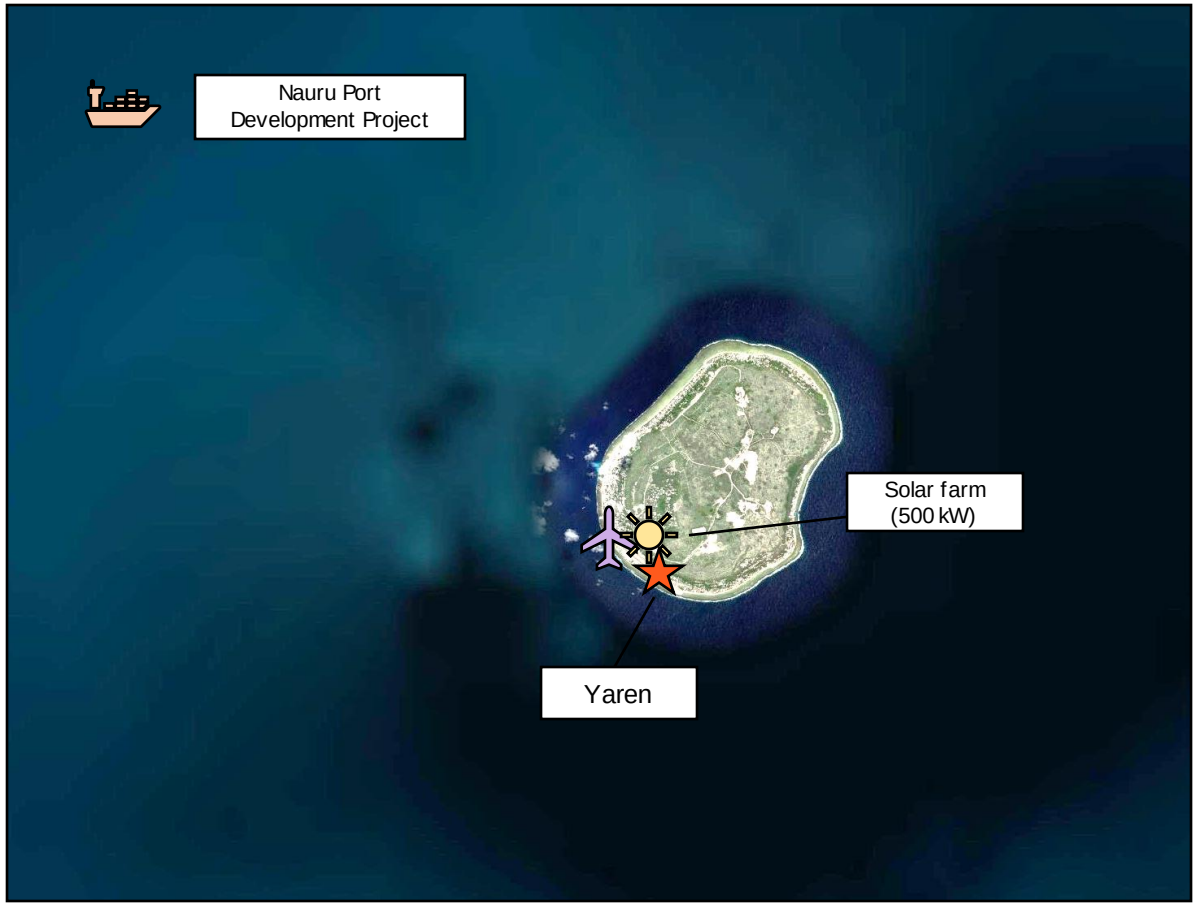
Targets

- Nauru's updated 2021 NDC includes key energy-related goals:
  - Achieve 50% renewable energy capacity.
  - Establish power grid capable of providing stable and affordable power.
  - Achieve 30% energy savings.
- Nauru is targeting net zero emissions by 2050 through the Climate Ambition Alliance.

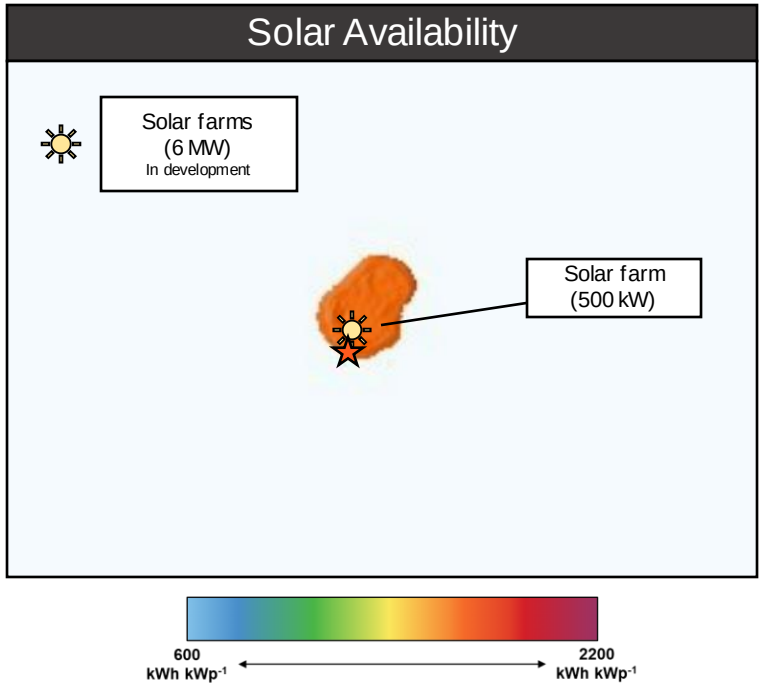


Legend

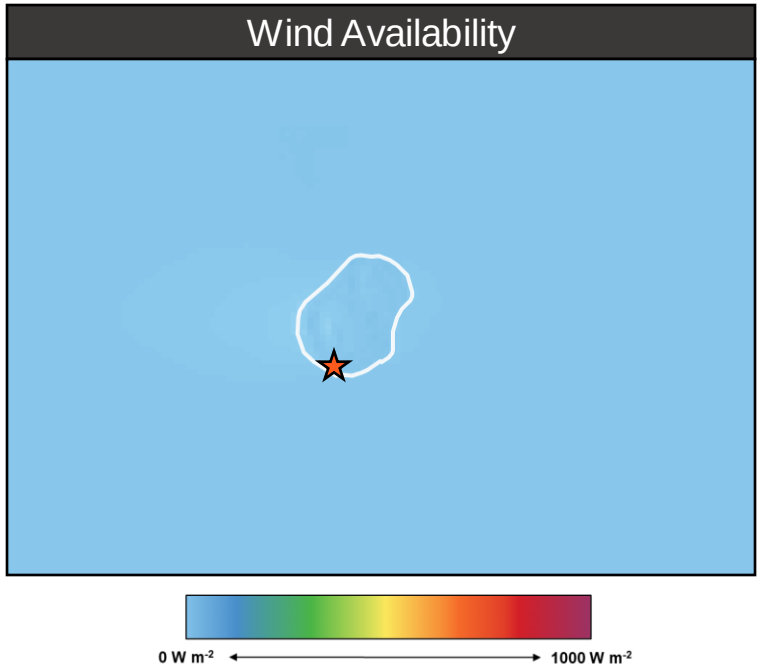
- Main city or town
- Main airport
- Main sea port
- Main hydroelectricity plant
- Main wind plant
- Main solar plant
- Main geothermal plant
- Main fossil fuel energy generator



Solar Availability



Wind Availability



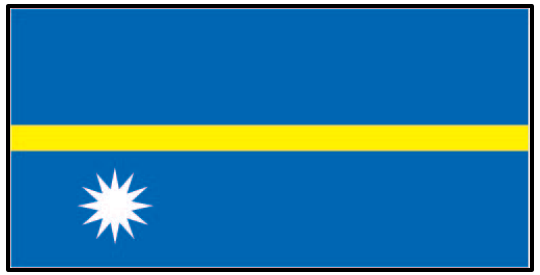
Population

- Nauru consists of a single island with an area only 21 km^2.
- Nauru has no official capital city; however, government offices are in the largest district of Yaren, the de facto capital, which has a population of around 1,100.

Renewable Energy Potential

- Nauru has very high solar potential, as evidenced by the range of solar PV projects planned.
- The wind potential of Nauru is very low (the lowest of the assessed PICTs).

- The production of 4,500 tpa of hydrogen would require around:
  - 0.22 TWh/yr of electricity
  - 26 MW of electrolyser capacity
  - 0.13 GL/yr of water



Nauru's Power to X Potential

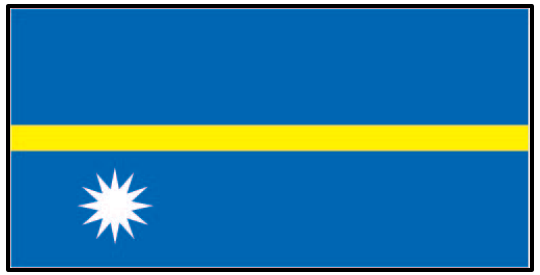
Nauru is heavily dependent on fossil fuels, making up 99% of its total energy usage. Nauru has strong solar potential, with a range of solar PV projects that could decarbonise 50% of electricity generation. Power to X represents an opportunity to assist in the decarbonisation of the transport sector, as well as the generation of electricity.

Existing Targets and Strategies for Decarbonisation

- Nauru's updated 2021 NDC includes key energy-related goals:
  - Achieve 50% renewable energy capacity.
  - Establish power grid capable of providing stable and affordable power.
  - Achieve 30% energy savings.
- Several strategies will be employed to achieve these targets, including:
  - The expansion of solar capacity, with the support of the United Arab Emirates, New Zealand and the European Union.
  - Installation of a 6 MW solar PV farm and a 5 MW battery storage system, with the support of the Asian Development Bank
  - Conduction of technical assessment of non-solar sources of renewable energy such as ocean thermal energy conversion and waste-to-energy.
  - Conduction of technical assessment of low-carbon transport options.
  - Promote energy efficient air conditioners and other appliances through an expansion of the Low Carbon Fund.
  - Conduct technical assessments to identify effective energy efficiency options for Nauru.
  - Rewire government buildings to maximize energy savings and encourage changes in usage behavior among government staff.
  - Adopt an Appliance Labeling and Energy Standard Program to encourage the import and uptake of low energy usage products.
  - Nauru Climate Change Policy: The Nauru Climate Change Policy will integrate Nauru's existing climate related policies into an overarching climate policy. It will set out the national climate objectives and strategy into a single government document, and the implementation plans to achieve them.

Figure 25. The 500 kW solar farm in Nauru.

Figure 26. Phosphate mining was the primary industry in Nauru.



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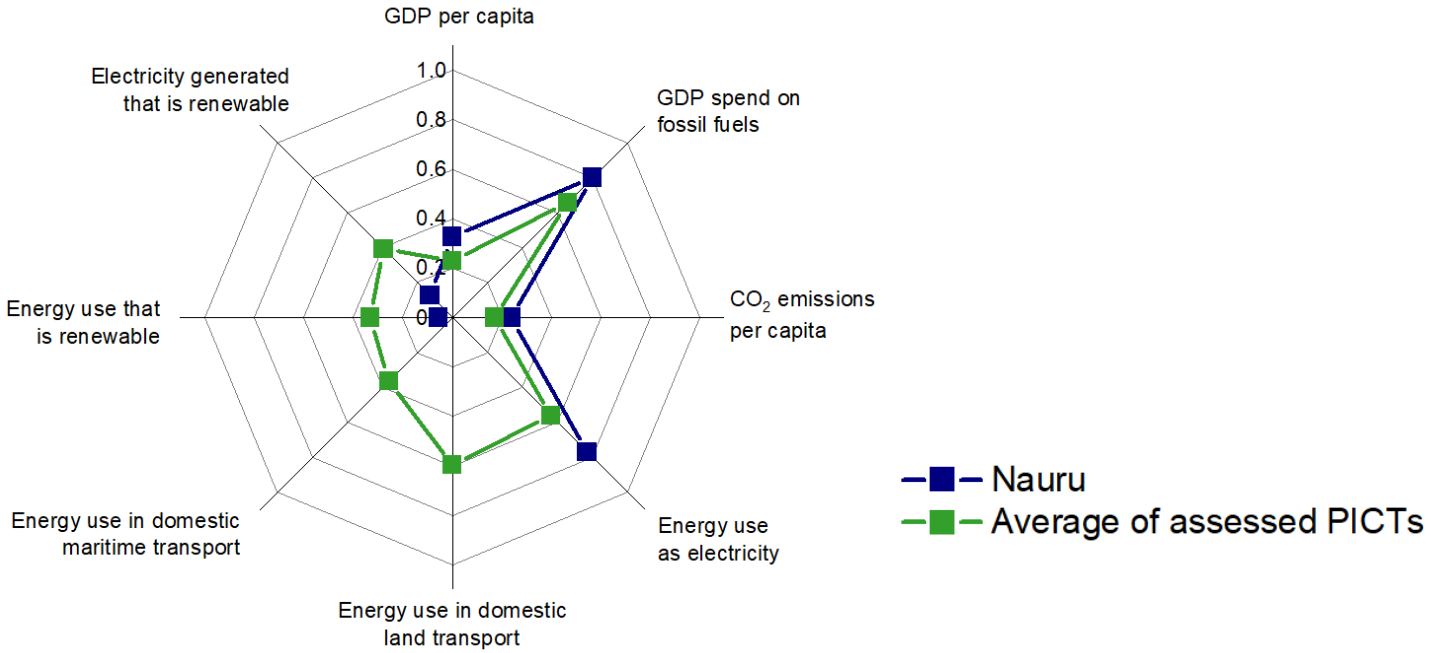
Competitive Advantage



- Nauru spends a relatively high proportion of its GDP on fossil fuels, leaving the country heavily exposed to volatile oil prices. In comparison to the assessed PICTS, renewables account for a small proportion of total energy use.
- Nauru has strong solar (highest of the PICTs) but low wind (14th highest in PICTs) energy potential with up to 100% energy accessibility/coverage.
- Transport and electricity generation accounts for the vast majority of CO_2 emissions, presenting an opportunity to heavily decarbonise through Power to X.

Critical Challenges

- Due to lack of marketable resources, and isolation from major international markets, Nauru is one of the most economically vulnerable countries in the world and sustainable development is a persistent challenge.
- The vast majority of homes and critical infrastructure in Nauru is located on the low-lying coastal areas.
- There is difficulty in decarbonising the transport sector, for example, shifting from individual transport to public transport has proven challenging, whilst the salty, corrosive environment affects infrastructure and vehicles.
- Key challenges for decarbonisation include:
  - No NDC net zero target for 2050.
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Human capacity.
  - Enabling policies.